3.0 WATERSHED CHARACTERIZATION

The purpose of this chapter is to provide a general description of the Salt Lake Countywide Watershed (Watershed), with the intent of identifying opportunities for implementation to improve the condition of the Watershed. A review of the physical, biological and chemical condition of the Watershed, as well as the social components (such as population growth and recreational use) will serve to identify areas that may be in need of some type of watershed project, or may respond well to project implementation. This chapter specifically addresses the following aspects of the Watershed: Population and Land Use, Social and Recreation, Geology and Soils, Groundwater, Climate, Hydrology, Geomorphology, Habitat, and Water Quality.

In general, best available information was used in the development of this characterization. In several cases, further data collection and analysis was conducted to provide additional information for use in assessing the Watershed, and identifying potential projects and management strategies. A discussion of regulatory and jurisdictional components is summarized to assist with the identification of strategic partners.

3.1 WATERSHED INFORMATION

The information in this chapter represents current and best available data relating to physical, biological and chemical components of the watershed. These data are analyzed to determine if they represent threats or sources of pollutants within a watershed, and that these attributes may need to be addressed to sustain the health and function of the watershed.

Gathering the existing information and the creation of a database, assists with the long-term tracking and statistical analysis required in the adaptive management process and provides the scientific basis for development of management strategies and restorative projects. It is acknowledged that data-gathering and analyses are a challenging and ongoing process, as not all data sets are updated, consistent or targeted. Through early discussions with stakeholders, data sources, data quality and limitations were identified and recognized.

Data presented herein broadly falls into the following categories: physical and natural features, land use and population, waterbody designations, classifications and chemistry as well as authorities and jurisdictions. Through the continual update of this baseline data, and the collection of additional data, assessment of the factors contributing to the health of the watershed will be reviewed and incorporated into the management process.

3.2 WATERSHED AREA

The Salt Lake Countywide Watershed (Watershed) drains 805.6 square miles (515,600 acres) (Figure 3.2.1). The Watershed is bounded on the east by the Wasatch Mountains, on the west by the Oquirrh Mountains, and on the south by the Traverse Range (Figure 3.2.2). Approximately 370 square miles (46% of the land) in the Watershed are in rugged mountain ranges and are largely undevelopable. Approximately 134.3 square miles (16.7%) of the Wasatch Mountains are protected to ensure drinking water quality for Salt Lake City and Sandy City. As a result, water quality management concerns in Salt Lake County vary from urban runoff in populated areas to headwaters recharge area protection, wilderness management, and dispersed recreation concerns in National Forests. The following are general descriptions of the: topography, cities, roads, streams, and canal systems in the Watershed.

3.2.1 Topography

The lowest elevation in the Watershed is found at the Great Salt Lake, which typically has an elevation of approximately 4,200 feet, depending on climate conditions. The highest elevation in the Watershed is Twin Peaks (between Big and Little Cottonwood Canyons) at 11,330 feet. The Wasatch Range to the east of the Jordan River has the highest elevations in the Watershed reaching levels over 11,000 feet. The Oquirrh Mountains to the west of the Jordan River, reach elevations of over 9,000 feet. The land surface between these ranges consists of a series of benches, each of which slope gradually away from the mountains and drop sharply to the next bench. For the purposes of this study, the Watershed was separated into two general segments that include the lower valley portion and the upper mountain portion. The valley portion is typically an urbanized area, while the

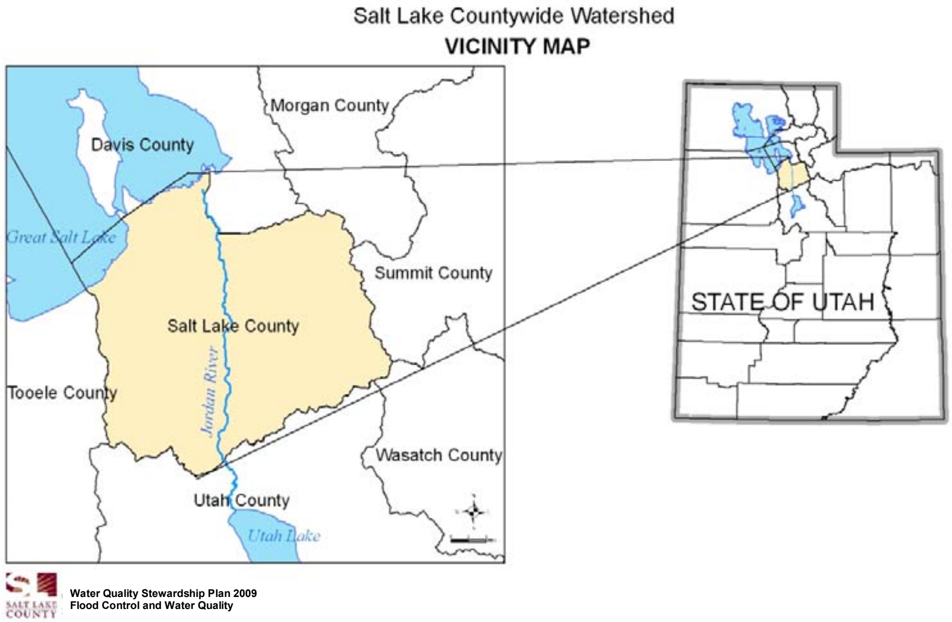


Figure 3.2.1 Salt Lake County Vicinity Map

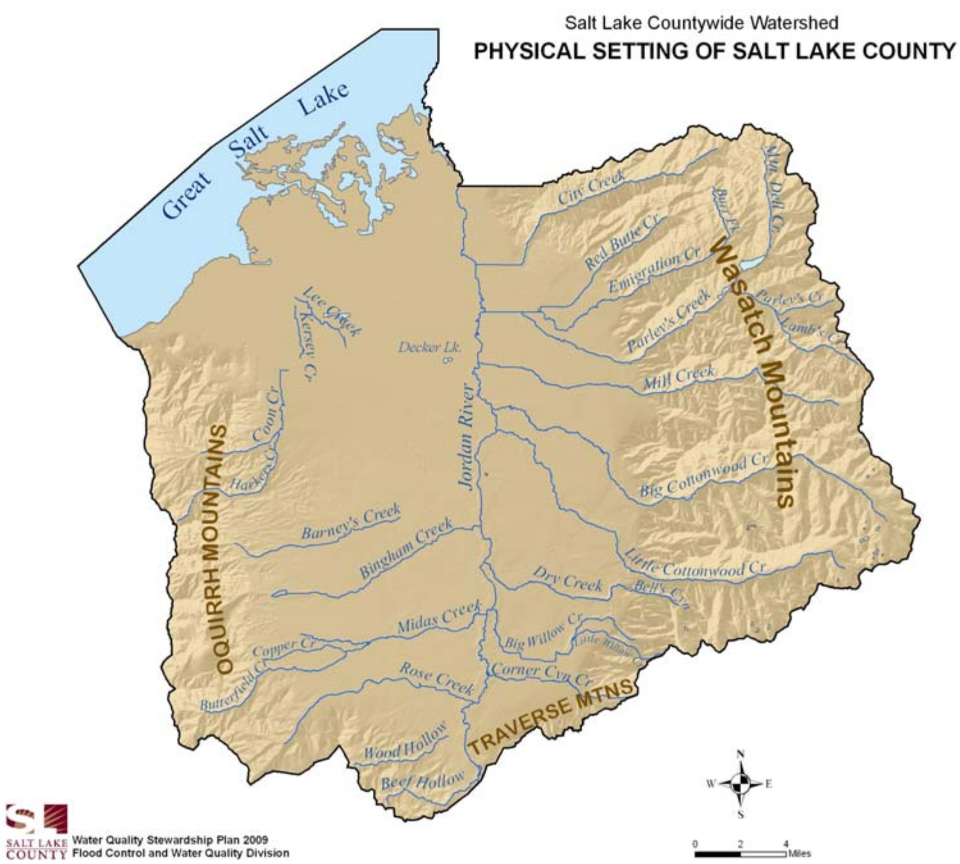


Figure 3.2.2 Physical Setting

mountain portion is less developed; although, there has been considerable impact from mining and recreational activities.

3.2.2 Cities

Sixteen (16) municipal governments have been incorporated in Salt Lake County (Table 3.2.1 and Figure 3.2.3). Of these cities, the largest in terms of land area is Salt Lake City with 110 square miles. However, the majority of land (461 square miles) is in the unincorporated area of Salt Lake County. The cities vary in age from less than three (3) years old to nearly 120 years old. As the County population continues to increase, a general trend toward incorporation and annexation is expected to continue.

3.2.3 Major Roads

Salt Lake County contains State (Class A), County (Class B), City (Class C), and dirt roads (Class D) with three (3) major interstate roads (Table 3.2.2). The major interstate roads are I-15 heading north and south, I-215, which makes a loop around Salt Lake County, and I-80, which trends east and west. The total mileage of roads in Salt Lake County is 4,287 miles, with the majority of these miles coming from unclassified arterial roads.

3.2.4 River and Streams

All surface waters in Salt Lake County are eventually conveyed to the Great Salt Lake. A portion of the surface waters drain directly to the Great Salt Lake, with the majority of water draining to the Jordan River, which eventually flows to the Great Salt Lake. The Jordan River initiates as an outlet from Utah Lake in Utah County and is conveyed north for 52 miles to the Great Salt Lake in Davis County. There are ten (10) major streams from the Wasatch Mountains and ten (10) streams from the Oquirrh Mountains. Additionally, several large tributaries have been individually named (Table 3.2.3). Although waters from these streams are eventually discharged to either the Jordan River or the Great Salt Lake, many are conveyed through urban areas by underground pipes or canal systems. Major streams range in size from less than three (3) miles to 44 miles in length and have unique flow and water quality conditions (Table 3.2.3). In addition to ecological, water quality, and

Table 3.2.1 Municipalities in Salt Lake County

Municipalities & Salt Lake County	Incorporation Date	Population (2005 WFRC population)	Acres	Square Miles
Town of Alta	1970	370	2,890	4.5
Bluffdale City	1978	12,005	10,795	16.9
Cottonwood Heights City	2005	36,016	5,754	9.0
Draper City	1978	34,146	13,870	21.7
Herriman City	1999	15,507	7,993	12.5
Holladay City	1999	25,685	4,976	7.8
Midvale City	1900	27,182	3,753	5.9
Murray City	1902	46,021	7,860	12.3
Riverton City	1946	32,104	8,081	12.6
Salt Lake City	1851	178,178	70,556	110.2
Sandy City	1893	89,641	14,649	22.9
South Jordan City	1935	40,318	14,156	22.1
South Salt Lake City	1938	21,421	4,452	7.0
Taylorsville City	1996	58,035	6,953	10.9
City of West Jordan	1941	138,390	20,695	32.3
West Valley City	1980	97,044	22,929	35.8
Unincorporated Salt Lake County		118,917	295,210	461.2
Total		**970,982**	**515,572**	**805.6**

[1] Town of Alta population from current census data (2000). This estimate is currently being reevaluated

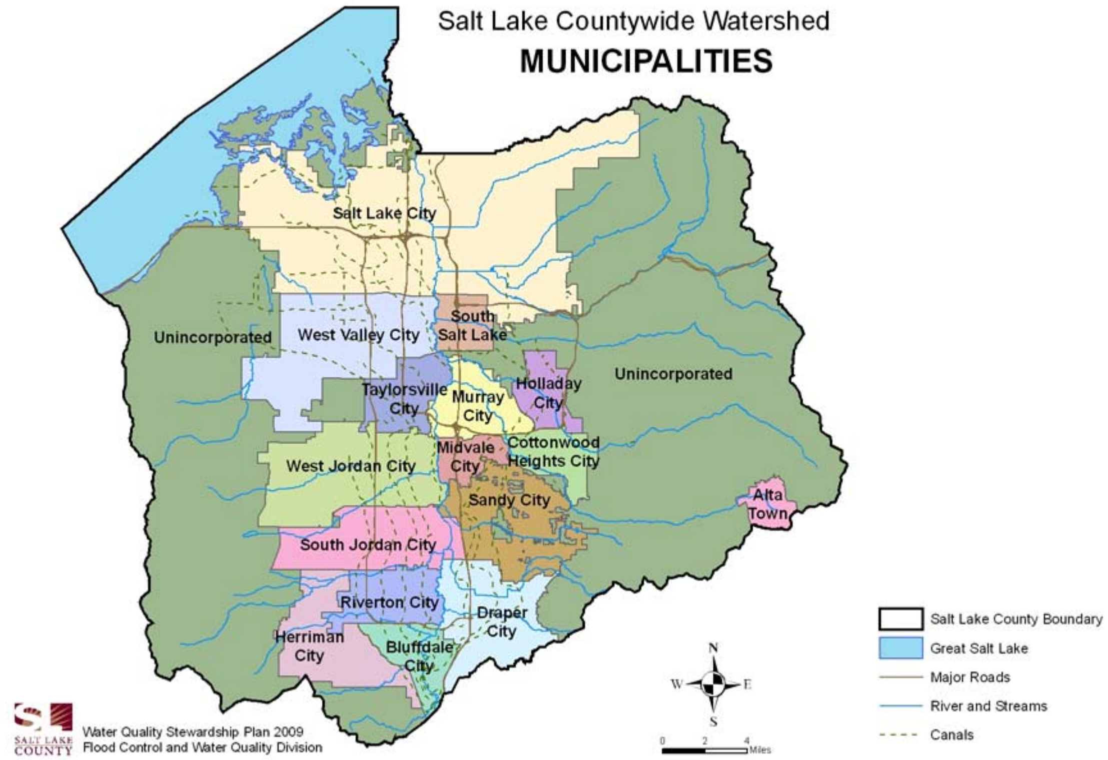


Figure 3.2.3 Municipalities

Table 3.2.2 Major Roads in Salt Lake County

Class	Management	Total Miles
A	State	652.4
B	County	180.8
C	City	523.3
D	Varies	58.0
Unclassified		2872.9
Total		**4,287.4**

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.

3.2.5 Irrigation and Drainage Canals

In addition to the streams and river found in Salt Lake County, an extensive irrigation canal system has been constructed in the valley. The first irrigation diversions were from City Creek and Parley's Creek followed by diversions from the Jordan River in 1850 for irrigation west of the river. Additionally, several dams have been constructed along the Jordan River; the first of which was constructed in 1859.

During irrigation season, Utah Lake discharges are diverted into a series of canal systems that were established for agricultural crop irrigation; however, several canals are no longer used for irrigation purposes. The canals generally run parallel to the Jordan River.

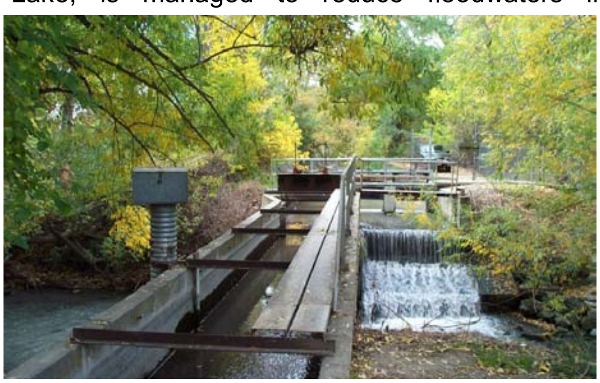
Three (3) major canal systems on the east side of the Jordan River (Jordan and Salt Lake Canal, East Jordan Canal, and Draper Irrigation Canal) and four (4) major canal systems on the west side of the river (Welby Jacobs Canal, Utah Lake Distributing Canal, Utah and Salt Lake Canal, and South Jordan Canal) are used as drainage facilities for flood control by municipalities and as conveyance facilities for water rights exchanges and irrigation water. Some of these canals eventually return water to streams, the Jordan River, and the Great Salt Lake. Many of these irrigation waters have primary water rights, which need to be met prior to use of these waters for culinary purposes. If Utah Lake water is not available for this purpose, well or stream waters

Table 3.2.3 Salt Lake County Streams and Rivers

Stream[1]	Watershed	Source	Flow Gauge Location	Average Flow Range (cfs)	Total Stream Miles
Barney's Creek	Barney's Creek	Oquirrh		NA	8.4
Beef Hollow	Jordan River	Oquirrh		NA	5.5
Big Cottonwood Creek	Big Cottonwood Creek	Wasatch	Cottonwood Ln.	11.1—45.9	24.2
Big Willow Creek	Willow Creek	Wasatch		NA	10.95
Bingham Creek	Bingham Creek	Oquirrh		NA	10.2
Burr Fork	Emigration Creek	Wasatch		NA	2.3
Butterfield Creek	Midas/Butterfield Creek	Oquirrh		NA	8.1
City Creek	City Creek	Wasatch	Memory Grove	1.9—7.5	11.8
Coon Creek	Coon Creek	Oquirrh		NA	7.8
Copper Creek	Midas/Butterfield Creek	Oquirrh		NA	5.3
Corner Canyon Creek	Corner Canyon Creek	Wasatch		NA	7.9
Dry Creek	Dry Creek	Wasatch		NA	9.1
Dry Creek (Bells Canyon)	Dry Creek	Wasatch		NA	2.4
Emigration Creek	Emigration Creek	Wasatch	Canyon Mouth	0.8—12.3	15.2
Harker's Canyon	Coon Creek	Oquirrh		NA	7.8
Jordan River	Jordan River	Utah Lake	9000 South	42.3—675	43.8
Jordan River	Jordan River	Tributaries	500 North	139—254	
Kersey Creek	Great Salt Lake	Oquirrh		NA	2.6
Lambs Canyon	Lambs Canyon	Wasatch		NA	5.3
Lee Creek	Great Salt Lake	Oquirrh		NA	4.0
Little Cottonwood Creek	Little Cottonwood Creek	Wasatch	Crestwood Park	13.1—32.7	22.3
Little Willow Creek	Willow Creek	Wasatch		NA	4.8
Midas Creek	Midas/Butterfield Creek	Oquirrh		NA	10.1
Mill Creek	Mill Creek	Wasatch	Canyon Avenue	8.6—20.5	18.5
Mountain Dell Canyon	Parleys Creek	Wasatch		NA	6.1
Parley's Creek	Parleys Creek	Wasatch	Suicide Park	3.2—20.0	19.4
Red Butte Creek	Red Butte Creek	Wasatch	1600 East	1.4—7.4	6.8
Rose Creek	Rose Creek	Oquirrh		NA	11.2
Willow Creek	Willow Creek	Wasatch		NA	15.9
Wood Hollow	Jordan River	Oquirrh		NA	5.1
				Total	296.7

[1] Streams include main stem tributaries in each watershed.
[2] Average flow for period 1999-2003.

may be required to meet these water rights. The Surplus Canal, which extends from the Jordan River (at 2100 South) directly to the Great Salt Lake, is managed to reduce floodwaters in downtown Salt Lake City. Approximately 70% of waters in the Jordan River can be diverted through the Surplus Canal at any given time.



Exchange and Overflow Structure: Jordan and Salt Lake Canal at Big Cottonwood Creek

Overflow Structure: North Jordan Canal at Bingham Creek

3.3 WATERSHED AND SUB-WATERSHED BOUNDARIES

For the purposes of the WaQSP, Salt Lake County has been delineated into seventeen (17) watersheds (Figure 3.3.1). These delineations were based on topography in the mountains and stormwater drainage areas in the valley. In order to provide increased resolution of specific issues and management practices throughout Salt Lake County, the watersheds were divided into twenty-seven (27) sub-watersheds based primarily on management practices and jurisdiction. These watersheds and sub-watersheds will function as planning units for the WaQSP, and are listed in Table 3.3.1.

View of Little Willow Creek drainage area from Lower Willow Creek Sub-Watershed

3.4 AUTHORITIES AND JURISDICTIONS

This section describes the main authorities and jurisdictional controls of federal, state, and municipal governments and agencies. In order to better characterize the authorities and jurisdictions that affect water supply, watershed health, and water quality, these agencies have been divided into three categories: Regulatory Agencies, Land Management Agencies, and Municipal Governments.

Table 3.4.1 presents an overview of the main authorities and jurisdictions granted to both regulatory and land management agencies within Salt Lake County that are integral with water quality. A more complete explanation of these legal authorities is outlined in Appendix A.

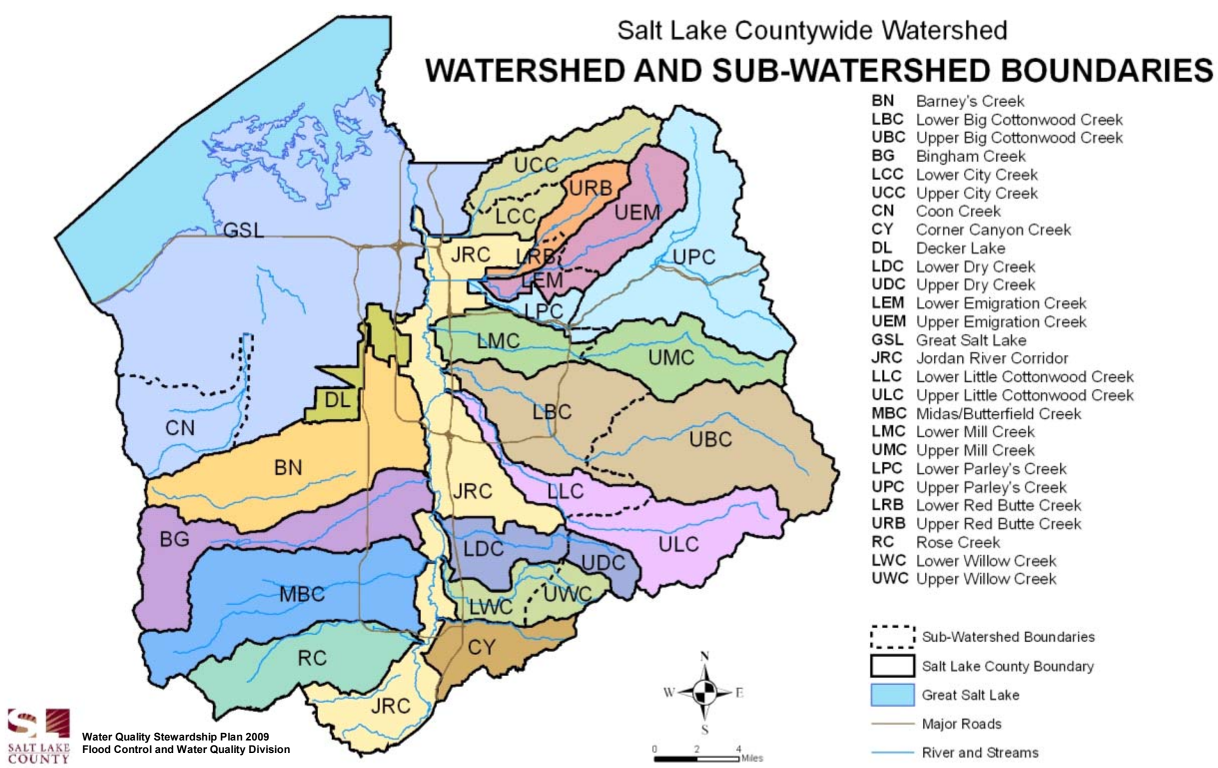


Figure 3.3.1 Watershed and Sub-Watershed Boundaries

Table 3.3.1 Watershed Delineation

Watershed	Sub-Watershed	Abbreviation	Drainage Area	
			Square Miles	Acres
Barney's Creek	Barney's Creek	BN	49.8	31,873
Big Cottonwood Creek	Upper Big Cottonwood Creek Lower Big Cottonwood Creek	UBC LBC	49.9 31.6	31,955 20,248
Bingham Creek	Bingham Creek	BG	36.2	23,172
City Creek	Upper City Creek Lower City Creek	UCC LCC	17.5 7.2	11,189 4,621
Corner Canyon Creek	Corner Canyon Creek	CY	14.6	9,344
Decker Lake	Decker Lake	DL	9.7	6,238
Dry Creek	Upper Dry Creek Lower Dry Creek	UDC LDC	6.1 13.4	3,878 8,557
Emigration Creek	Upper Emigration Creek Lower Emigration Creek	UEM LEM	18.2 5.8	111,635 3,742
Great Salt Lake of Salt Lake County	Great Salt Lake of Salt Lake County Coon Creek	GSL CN	215.0[1] 22.5	137,613[1] 14,409
Jordan River Corridor	Jordan River Corridor	JR	67.6	43,239
Little Cottonwood Creek	Upper Little Cottonwood Creek Lower Little Cottonwood Creek	ULC LLC	27.1 12.7	17,366 8,141
Midas/Butterfield Creek	Midas/Butterfield Creek	MBC	50.3	32,173
Mill Creek	Upper Mill Creek Lower Mill Creek	UMC LMC	21.7 15.2	13,915 9,729
Parley's Creek	Upper Parley's Creek Lower Parley's Creek	UPC LPC	52.0 6.4	33,272 4,112
Red Butte Creek	Upper Red Butte Creek Lower Red Butte Creek	URB LRB	8.4 2.6	5,403 1,652
Rose Creek	Rose Creek	RC	27.6	17,654
Willow Creek	Upper Willow Creek Lower Willow Creek	UWC LWC	7.0 9.4	4,450 6,001
		Total	805.6	515,578

[1] Area of Great Salt Lake Drainage within Salt Lake County.

3.4.1 Federal Regulatory Agencies

Army Corps of Engineers Section 404 of the Clean Water Act grants primary authority for regulation of wetland development to the U.S. Army Corps of Engineers (USACE). Currently, the USACE defines wetlands as "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted to life in saturated soil conditions" (USACE, 1987). USACE requires that three (3) conditions be present on site to be considered a jurisdictional wetland: presence of hydric soils, indicators of hydrology, and a predominance of wetland vegetative species, .

Additionally, the permitting authority of the USACE encompasses all activities affecting waters of the United States. Waters of the United States include surface waters such as navigable waters and their tributaries, all interstate waters and their tributaries, natural lakes, all wetlands adjacent to other waters, and all impoundments of these waters.

Federal Emergency Management Agency (FEMA) The Disaster Relief Act of 1974 established the process of presidential disaster declarations as FEMA was established. Although

Table 3.4.1 Authorities and Jurisdictions Summary

Agency	Management Responsibility	Relevant Statutes
Salt Lake County		
Flood Control	County may contract with the United States for the construction of any flood control project within the County.	17-8-1 Utah Code and Title 17, S. L. County Code.
	County legislative body may construct and maintain facilities for the control of storm and floodwaters. County executives shall enforce all laws and regulations against the pollution of water in natural streams, canals and lakes.	17-08-05 Utah Code and Title 17, S. L. County Code.
	Area-wide water quality management agency. Prepares twenty-year master plan for the preservation and enhancement of water quality.	Enabling Ord. No. 615, Oct. 31, 1977. 17-8 Utah Code 17-06-010, 17-4-010 and Title 17-04-020 S.L. County Code.
	County legislative body may declare a drought emergency and appropriate money to address the emergency.	Title 17-08-07 Utah Code
	County may purchase water rights or acquire real estate to obtain water for county purposes.	Title 17-50-310 Utah Code
	A permit is required to use a designated flood control facility.	Title 17-08-020 S.L. County Code
	Designated county storm drainage and flood control system.	Title 17-08-040 S. L. County Code.
Salt Lake Valley Health Department	Enforces all laws and regulations against the pollution of water in natural streams, canals and lakes.	Title 17-06 S. L. County Code.
Planning and Development Services	Authority to regulate land use, prepare general plans and enact ordinances.	17 Utah Code and Title 18 and 19 S. L. County Code.
Cities - S.L. County has no specific authority and control		
Public Works	Extraterritorial jurisdiction over streams from which water supply is taken. Acquisition of water sources. Water service provider may operate waterworks and sell surplus water beyond city limits. Control and regulation of water and watercourses leading to the city.	Utah Constitution Article XI, Section 6. Title 10-8-14,15,16,18, Utah State Code
Community Development	Land Use Regulations Enactment of Ordinances	Section 10, Utah State Code
State of Utah—S.L. County has no specific authority and control. May have a tie to the planning process.		
Department of Environmental Quality, Division of Water Quality and Division of Drinking Water	Surface water discharges Wastewater facilities construction UPDES permits TMDL Watershed and water quality Ground water protection	Title 19-5-107 and 73-3-29 Utah Code
Department of Natural Resources (DNR), Division of Water Rights	Regulates appropriation and distribution of water based on water rights.	Title 73-1-1, Utah Code
DNR, Division of Water Resources	Water conservation plan required Conservation Development Protection of Water Resources	Several chapters of the Utah Code Title 73, Utah State Code
DNR, Forestry, Fire & State Lands	Owns and manages the bed of the Jordan River	Section 65A Utah Code Administrative Rule R652-2-200

Table 3.4.1 Authorities and Jurisdictions Summary Table—Continued

Agency	Management Responsibility	Relevant Statutes
Federal Government S.L. County has no specific authority and control.		
Department of Agriculture, U. S. Forest Service	National Forest and Grasslands	Forest Reserve Act of 1891 and the National Forest Management Act
Department of Interior, Bureau of Land Management	Public Lands and sub-surface minerals	Federal Land Policy and Management Act 1976, 43 U.S. C.1744 et seq.
Bureau of Reclamation	Dams, reservoirs and impoundments, "wholesale" supplier of surface water withdrawn for irrigation.	44 U.S.C. 2593 et seq.
Department of Defense, Army Corp Of Engineers	Section 404, Clean Water Act Waters of the United States	Survey Act of 1824, Rivers and Harbors Act
Environmental Protection Agency	Federal Water Pollution Control Clean Water and Safe Drinking Water Acts Solid Waste Disposal Act CERCLA/Superfund	33 U.S.C. 1251 et seq.
Federal Emergency Management Agency (FEMA)	Federal Disaster Response	Disaster Relief Act PL100-707

Source: Salt Lake County District Attorney, 2007

numerous agencies have been involved in handling disasters and emergencies in the past, most of them were consolidated into the Federal Emergency Management Agency (FEMA) in 1979. In November of 1988, the Disaster Relief Act of 1974 was amended to establish statutory authority for most Federal disaster response activities, especially as they pertain to FEMA.

FEMA is part of the U.S. Department of Homeland Security (DHS) and has a broad mission to "reduce the loss of life and property." The major regulatory authority exercised by FEMA that affects water quality and watershed function is the delineation and managment of floodplain zones. As such, FEMA works closely with State and local officials to identify flood hazard areas and flood risks. When a community receives notice of a Special Flood Hazard Zone (SFHZ), or if the community chooses to join the National Flood Insurance Program (NFIP), it must adopt and enforce minimum floodplain standards. The floodplain management design requires that new development prevent the threat of flooding to new and existing buildings.

Communities must ensure that their adopted floodplain management ordinance(s) and enforcement procedures meet program requirements. The regulatory requirements set forth by FEMA are the minimum measures acceptable for NFIP participation. If a local community or State adopts requirements that are more stringent, the local requirements take precedence over the minimum regulatory requirements established by FEMA.

Environmental Protection Agency (EPA) The Environmental Protection Agency (EPA) "leads the nation's environmental science, research, education and assessment efforts" (EPA, website). The Agency is responsible for numerous activities that include developing and enforcing regulations and performing environmental research. The two (2) most applicable statutes affecting water quality and watershed management are the Clean Water Act (U.S. Congress, 1972) and the Safe Drinking Water Act (U.S. Congress, 1974). States are typically given principal responsibility for implementing the provisions of these federal acts. The State of Utah has been granted primacy for the Clean Water Act (CWA).

The CWA is the cornerstone of water quality protection in the United States; however, the Act does not deal directly with groundwater or with water quantity issues. The statute employs a variety of regulatory and non-regulatory tools to reduce pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage stormwater runoff. These tools are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters so that they can support "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water."

For many years following the passage of the CWA, the EPA focused primarily on the chemical aspects of water quality. However, during the last decade, more attention has been given to measuring and protecting the physical and biological components of stream health. In addition, previous efforts have focused on regulating point source discharges such as municipal sewage plants and industrial facilities. With recent innovations and increased understanding, nonpoint source pollution have been increasingly addressed.

Additionally, CWA programs have been shifting from a program-by-program, source-by-source, pollutant-by-pollutant approach to a more holistic watershed-based approach. A full array of issues is addressed in this approach, not just those subject to CWA regulatory authority. Involvement of stakeholder groups in the development and implementation of strategies for achieving and maintaining state water quality and other environmental goals is a hallmark of this approach.

The Safe Drinking Water Act (SDWA) focuses on all waters that are actual or potential sources for drinking water use. As part of this, the EPA establishes health-related drinking water standards and encourages States to establish nuisance-related standards. In order to fulfill the primacy role established through the EPA, the following State agencies have been given regulatory authority in relation to water quality and water supply: Division of Water Quality (DWQ), Division of Water Rights (DWRi), Division of Drinking Water (DDW) and Division of Water Resources (DWRe).

3.4.2 State of Utah Regulatory Agencies

Department of Environmental Quality (DEQ)Division of Water Quality (DWQ) The Division of Water Quality (DWQ) is responsible for regulating surface water discharges, wastewater treatment, reuse facilities, stormwater, and groundwater in the State of Utah. As a regulatory division, the DWQ: 1) oversees the Utah Pollutant Discharge Elimination System (UPDES) program, 2) monitors water quality on a five (5) year rotating cycle throughout the State, 3) establishes water quality standards and sets beneficial use designations, 4) oversees Total Maximum Daily Load (TMDL) Studies conducted throughout the State, and 5) administers Groundwater Discharge Permit and Underground Injection Control (UIC).

Department of Natural Resources (DNR) Division of Water Rights (DWRi) The Utah State Engineer's Office was created in 1897. In 1963, the State Engineer's Office was renamed the Division of Water Rights (DWRi), which currently serves as the chief water rights administrative office. The DWRi is the state agency that regulates water right appropriations (i. e. the designation of a legal right to take possession of a specific water at a specific time) and distribution of water in the State of Utah. A regional engineer for the Utah Lake – Jordan River Basin oversees these activities in Salt Lake County.

Water rights are granted to use water based on: 1) quantity, 2) source, 3) priority date, 4) nature of use, 5) point of diversion, and 6) physically putting water to beneficial use. Beneficial uses are defined by the DWRi as "the use of water for one or more of the recognized purposes including but not limited to, domestic, municipal, irrigation, hydropower generation, industrial, commercial, recreation, fish propagation, and stockwatering" (DWRi, website).

As with most western States, the DWRi functions under the principal that that those who first made beneficial use of water should be entitled to continued use. This principal is known as the Doctrine of Prior Appropriation. The Doctrine of Prior Appropriation means that those with earliest priority dates, who have continuously used the water since that time, have the right to collect and distribute waters from a certain source before those entities with later priority dates. Currently, the DWRi has determined that all surface waters in Salt Lake County are fully appropriated.

In addition to overseeing water right appropriations, the DWRi administers a Stream Alteration Program that regulates activities affecting the bed and banks of natural streams. Examples of activities that may affect the bed and bank of streams include: bridge construction, pipeline installation, discharges to, dredging and sluicing, and the construction of culverts.

Department of Natural Resources (DNR), Division of Water Resources (DWRe) The Division of Water Resources (DWRe) is responsible to "promote the orderly and timely planning, conservation, development, utilization and protection of Utah's water resources." The DWRe evaluates the States' water resources and supply demands on a river-basin basis. A Jordan River Basin Plan was published in 1997. This plan summarizes numerous subjects including: water supply and use, management, regulations and institutional considerations, water funding, water planning and development, agricultural water, and drinking water.

3.4.3 Federal Land Management Agencies

US Forest Service The United States Forest Service (USFS) is the largest land manager of Federal land in Salt Lake County. The Wasatch-Cache National Forest (WCNF) encompasses nearly 1.3 million acres, 78,893 acres of which is in Salt Lake County. In total, USFS land comprises 62% of the land in the Wasatch Mountains. Provisions of the Wilderness Act of 1964, the Endangered American Wilderness Act of 1978, and the Utah Wilderness Act of 1984, designated three (3) wilderness areas within Salt Lake County (Mount Olympus, Twin Peaks and Lone Peak, and Deseret Peak).

Through the *Wasatch-Cache National Forest Land and Resource Management Plan* (USDA, 2003), the USFS established long-term management practices to sustain the water supply resources and provide opportunities for recreation in the Wasatch-Cache National Forest.

Additionally, two (2) congressional acts established a special relationship between the USFS and Salt Lake City regarding watershed management strategies and objectives. Congress directed the USFS, under the Secretary of Agriculture, to administer the national forest lands in cooperation with Salt Lake City for the purpose of storing, conserving, and protecting these lands. The USFS was also granted authority to prescribe and enforce regulations to protect the water supply of Salt Lake City.

Bureau of Land Management (BLM) The Bureau of Land Management (BLM) is an agency of the U.S. Department of the Interior that manages public lands and sub-surface minerals. The BLM administers public lands within a framework of numerous laws. The most comprehensive of these is the Federal Land Policy and Management Act (FLPMA) of 1976. Through FLPMA, Congress made it clear that the public lands should be held in public ownership and managed for "multiple use," defined as the management of the public lands and their various resource values so that they are utilized in the combination that will best meet the present and future needs of the American people" (FLPMA, 1976). All BLM policies, procedures and management actions must be consistent with FLPMA and the other laws that govern use of the public lands. The BLM manages 23 million acres of land in the State of Utah. This represents approximately 42 percent of all lands within the State. Within Salt Lake County, the BLM manages 2,375 acres. Originally, BLM lands were valued principally for the commodities that could be extracted from them (e.g. minerals and livestock forage). More recently, recreational opportunities, along with natural, historical, and cultural resources protection, are management goals.

3.4.4 State of Utah Land Management Agencies

Department of Natural Resources, Division of Forestry, Fire and State Lands Pursuant to Utah Code Title 65A and Utah Administrative Rule R652, the State of Utah owns and has sovereignty over the bed of the Jordan River and the Great Salt Lake. The Division of Forestry, Fire and State Lands (DFFSL) administers these State lands in the public trust. The overarching management objectives of DFFSL is to protect and sustain the trust resources, while providing for reasonable beneficial uses of the State lands consistent with their long-term protection and conservation. Any beneficial use of public trust resources is subsidiary to long-term conservation of the resources. The DFFSL permits uses, grants easements, and leases land for specific beneficial uses of the State sovereign lands and resources.

Department of Natural Resources, Division of Parks and Recreation The Division of Parks and Recreation (DPR) manages three (3) state parks within Salt Lake County: 1) Great Salt Lake State Marina, 2) Jordan River OHV Park and Modelport, and 3) This is the Place Heritage Park. The DPR administers the State of Utah off-highway vehicle, boating, and trails programs and works to provide access to waterways and trails, while promoting education, safety, and resource protection.

Department of Natural Resources, Division of Wildlife Resources The Division of Wildlife Resources (DWR) has authority for managing and conserving wildlife in, on and around the Great Salt Lake and the streams and rivers in the State of Utah. The DWR issues hunting permits and fishing licenses pursuant to Utah Code Title 23 "Wildlife Resources Code of Utah" and Utah Administrative Rule R657. DWR also manages the Farmington Bay Waterfowl Management Area (WMA) within Salt Lake County. The Farmington Bay WMA comprises over 12,000 acres of wetlands along the Great Salt Lake shorelands.

3.4.5 Municipal Governments

3.4.5.1 Cities

The Utah Constitution, Article XI, Section 5, authorizes the state legislature to classify cities in proportion to their populations. Cities are subsequently granted authority over watersheds according to this classification. The Utah Constitution also gives cities the authority to own and develop water rights. State statute allows cities to "sell and deliver the surplus product or service capacity of any such works, not required by the city or its inhabitants, to others beyond the limits of the city" [Utah Code Ann, 10-18-14(1)] and has granted specific statutory authority to acquire water, waterworks, and associated property to all cities within the State. Utah statutes also grant extraterritorial jurisdiction to cities that allow substantial discretion in the management of watersheds to protect drinking water supply sources.

Salt Lake City, West Valley City and Sandy City, the only first class cities in Salt Lake County, have been given authority for watershed protection from the Utah Constitution, Utah statutes, and United States statutes. Currently, Salt Lake City and Sandy City have extraterritorial jurisdiction in the Wasatch Canyons. This jurisdiction allows Salt Lake City to store, conserve, and protect the Wasatch Mountain streams from pollution. As such, the City maintains principal management responsibility for watershed protection in the

Wasatch Canyons and owns approximately 90 percent of the rights to waters entering the Salt Lake Valley. Management responsibility of land and water within watershed boundaries includes the right to protect waters from activities that are detrimental to water quality and quantity. First class cities may enact ordinances necessary to protect the watershed and prevent pollution or contamination of the streams or watercourses in which the inhabitants of the cities derive their water. Sandy City also manages its headwater resources through its extraterritorial jurisdiction (UAC, 10-8-15). The area encompassed by the Sandy City Watershed includes seven canyons used by the City as culinary water sources. The canyons are: Little Cottonwood, Bell, Middle Fork of Dry Creek, South Fork of Dry Creek, Rocky Mouth, Big Willow and Little Willow.

Finally, cities and local municipal governments are granted jurisdiction over land use planning and development. Therefore, each city has authority to regulate land use within its boundary. Cities also provide stormwater management strategies to meet municipal stormwater discharge permits and to promote drinking water source protection policies.

3.4.5.2 Salt Lake County

Salt Lake County has land use authority over unincorporated areas of the County and provides services to residents and industries located in their jurisdiction. Below is a summary of jurisdictions related to watershed management.

Salt Lake County Planning and Development Services Division Salt Lake County receives its general land use authority from the State of Utah through Title 17 of the Utah State Code. The Code gives authority to all counties to enact ordinances, land use controls, and develop agreements that they consider necessary or appropriate for the use and development of land within the unincorporated area of the County. These controls or agreements include: resolutions, rules, restrictive covenants, easements, development agreements, open space designation, structures, buildings, energy-efficiency, air quality, transportation, and infrastructure.

Specific to watershed and water quality concerns, Salt Lake County has principal responsibility for land use and building permit decisions on private lands in the Wasatch Mountains. Explicit requirements need to be met when developing in the foothills and canyons of the Wasatch Mountains. These requirements are outlined in the Foothills and Canyons Overlay Zone (FCOZ) ordinance. This Zone encompasses the entire Wasatch Mountain area within Salt Lake County (Figure 3.4.1). The Planning and Development Services Division of the Salt Lake County Public Works Department administers FCOZ. The Division also coordinates the interagency site plan and development approval process for parcels within the FCOZ boundary.

In addition to administering FCOZ, the Planning and Development Services Division is responsible for the preparation of general plans to guide development in the unincorporated areas of the County. The Division also prepares amendments to zoning ordinances and reviews development proposals for compliance with stormwater runoff and geologic hazards, issues building permits, and inspects building for compliance with building codes.

Salt Lake County Flood Control & Engineering Title 17 of the Salt Lake County Code of Ordinances establishes the Division of Flood Control and Water Quality within the Public Works Department. The ordinance identifies the Countywide Flood Control Facilities and establishes the Jordan River meander corridor and requirements for land development within the river corridor. Requirements for the construction of storm drains are also outlined in this ordinance.

In order to effectively maintain Countywide Facilities, Salt Lake County can promulgate regulations to prevent the destruction or obstruction of these channels, storm sewers and drains, and pollution of water in natural streams, canals, and lakes. By ordinance, counties can also provide for the protection and use of flood channels, flood plains, streams, and canals. As such, counties may establish boundaries for flood channels and floodplains.

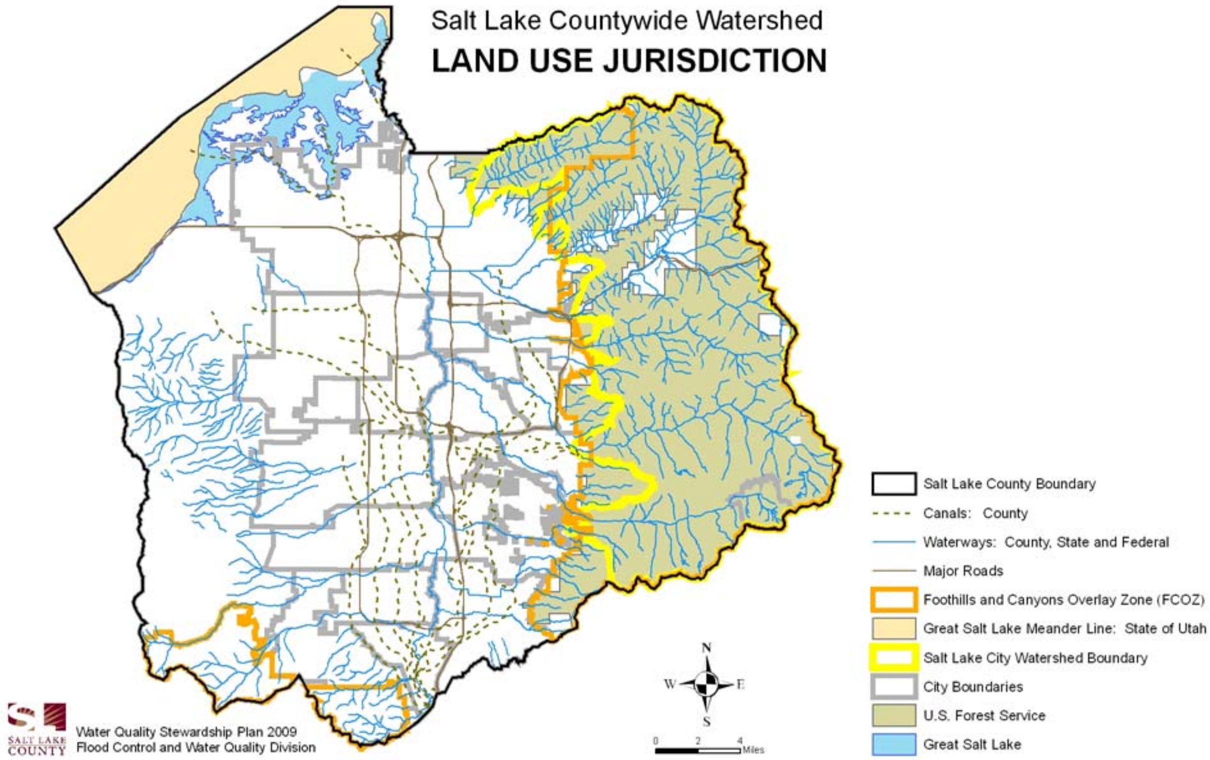


Figure 3.4.1 Jurisdictional Boundaries in Salt Lake County

3.5 POPULATION AND LAND USE

Wasatch Front Regional Council (WFRC), the local Metropolitan Planning Organization (MPO), and Stantec Consulting developed the population and land use data used in this analysis. The population data was developed by WFRC and organized by Traffic Analysis Zones (TAZ) (WFRC, 2006). A TAZ is a special area delineated by state and/or local transportation officials for tabulating traffic-related data, especially journey-to-work and place-of-work statistics. Several TAZ's usually make up a census block or census tracts.

Additionally, WFRC has compiled city land use plans to create a countywide, future land use dataset. Although WFRC has compiled and consolidated future land use plans, they did not have an existing land use dataset. Therefore, Stantec Consulting modified an existing land use dataset to be compatible with WFRC's future land use. Changes in population, population density and land use were identified by comparing existing and future population and land use information.

3.5.1 Population

Population forecasts prepared by WFRC for Salt Lake, Weber, and Davis Counties include population in 2005 and in 2030. According to WFRC, the most accurate population numbers are the city population projections (Table 3.5.1). However, this data is based on TAZ units. The computer model WFRC used to calculate these populations required manipulation of the TAZ data.

Utah State Capital Building, Great Salt Lake Sub-Watershed

When the entire TAZ was within a city boundary, the population was included in the City's population projection. Where a TAZ crossed a municipal boundary the population for that TAZ was not included in the city analysis. Although this data may not be completely accurate, the WFRC information was used "as is".

Salt Lake County's population was estimated at 970,612 in 2005 (WFRC, 2005). This number is expected to grow to 1,381,519 by 2030, an increase of 410,907 people or a yearly increase of 16,436 people. Table 3.5.1 shows population projections for each city and unincorporated Salt Lake County. Although Salt Lake City and the unincorporated area of Salt Lake County are anticipated to continue as the most populous areas of the County, cities in the southwestern region of the County are anticipated to experience the highest percent changes in population by 2030 (e. g. Bluffdale 441%, Herriman 295%, Riverton 161%).

3.5.1.1 Sub-Watershed Population and Density Change

In order to examine population trends by sub-watersheds, the TAZ data was manipulated using Geographic Information System (GIS) software. Municipal boundaries follow roads and other

Table 3.5.1 Wasatch Front Regional Council Current and Projected Population

	Population Estimate by Year					
Cities	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Town of Alta	Population data not available through WFRC					
Bluffdale City	12,005	28,720	36,595	43,091	48,227	52,900
Cottonwood Heights City	36,016	36,187	37,970	39,816	41,950	43,991
Draper City	34,146	38,341	40,550	42,800	44,559	46,256
Herriman City	15,507	23,983	31,977	38,303	42,142	45,686
Holladay City	25,685	29,045	30,294	31,606	32,256	32,891
Midvale City	27,182	35,816	39,552	43,126	43,876	44,610
Murray City	46,021	54,568	58,976	63,199	67,041	70,693
Riverton City	32,104	35,447	40,460	45,080	48,541	51,793
Salt Lake City	178,178	191,386	192,986	195,263	197,681	200,051
Sandy City	89,641	88,350	89,534	91,023	92,613	94,170
South Jordan City	40,318	57,631	70,407	81,393	90,105	98,150
South Salt Lake City	21,421	22,722	25,023	27,232	29,187	31,031
Taylorsville City	58,035	39,657	62,255	64,981	66,061	67,119
Unincorporated SL County	138,390	125,526	147,028	166,319	192,478	215,603
City of West Jordan	97,044	101,477	110,208	118,738	125,909	132,730
West Valley City	118,917	124,452	131,582	138,847	146,543	153,890
Total	970,612	1,053,258	1,145,337	1,230,817	1,309,169	1,381,519

Source: WFRC, 2006

manmade features. Alternatively, sub-watershed boundaries follow ridgelines and natural features. Where a TAZ crossed a sub-watershed boundary the population was divided proportionally between the transecting watersheds. Projected population and population density are therefore available for sub-watersheds (Table 3.5.2). Although TAZ data is complete for the valley portion of the County, it has not been developed for the mountain areas. Therefore, additional descriptions of mountain population conditions are provided in Section 3.5.1.2.

The Jordan River Corridor (247,465) and Barney's Creek (200,372) Sub-Watersheds are anticipated to have the highest populations in 2030. The largest change in population size is likely to occur within the Midas/Butterfield Creeks (100,844), Barney's Creek (70,646), Jordan River Corridor (57,229), and Great Salt Lake (48,436) sub-watersheds (Figure 3.5.1). The Lower Red Butte and Lower Big Cottonwood Creek Sub-Watersheds follow those.

In addition to city and sub-watershed population projections, percent population change and

Table 3.5.2 Projected Population per Sub-Watershed

	Change in Population by Sub-watershed 2005 - 2030			
Sub-Watershed	2005	2030	Population Change	Percent Change
Barney's Creek	129,731	200,377	70,646	35.3
Upper Big Cottonwood Creek	65	124	59	47.6
Lower Big Cottonwood Creek	92,257	118,722	26,465	22.3
Bingham Creek	46,710	83,162	36,452	43.9
Upper City Creek	1,352	1,585	223	14.8
Lower City Creek	11,727	13,427	1,700	12.7
Coon Creek	4,228	8,551	4,328	50.5
Corner Canyon Creek	16,645	32,658	16,013	49.1
Decker Lake	60,561	67,262	6,701	10
Upper Dry Creek	748	1,541	793	51.5
Lower Dry Creek	48,460	63,344	14,885	23.5
Upper Emigration Creek	239	282	43	15.3
Lower Emigration Creek	20,717	22,526	1,809	8.1
Great Salt Lake of Salt Lake County	123,546	171,983	48,436	28.2
Jordan River Corridor	200,236	257,465	57,229	22.3
Upper Little Cottonwood Creek	1,072	1,904	831	43.7
Lower Little Cottonwood Creek	31,303	42,728	11,425	26.8
Midas/Butterfield Creeks	39,750	140,594	100,844	71.8
Upper Mill Creek	423	476	53	11.2
Lower Mill Creek	76,222	88,286	12,064	13.7
Upper Red Butte Creek	379	422	42	10
Lower Red Butte Creek	8,111	8,519	408	4.8
Upper Parley's Creek	267	308	41	13.4
Lower Parley's Creek	22,817	25,260	2,443	9.7
Rose Creek	12,550	48,218	35,668	74
Upper Willow Creek	1,196	2,343	1,147	49
Lower Willow Creek	17,283	27,112	9,829	36.3

Source: Wasatch Front Regional Council TAZ Data, 2006

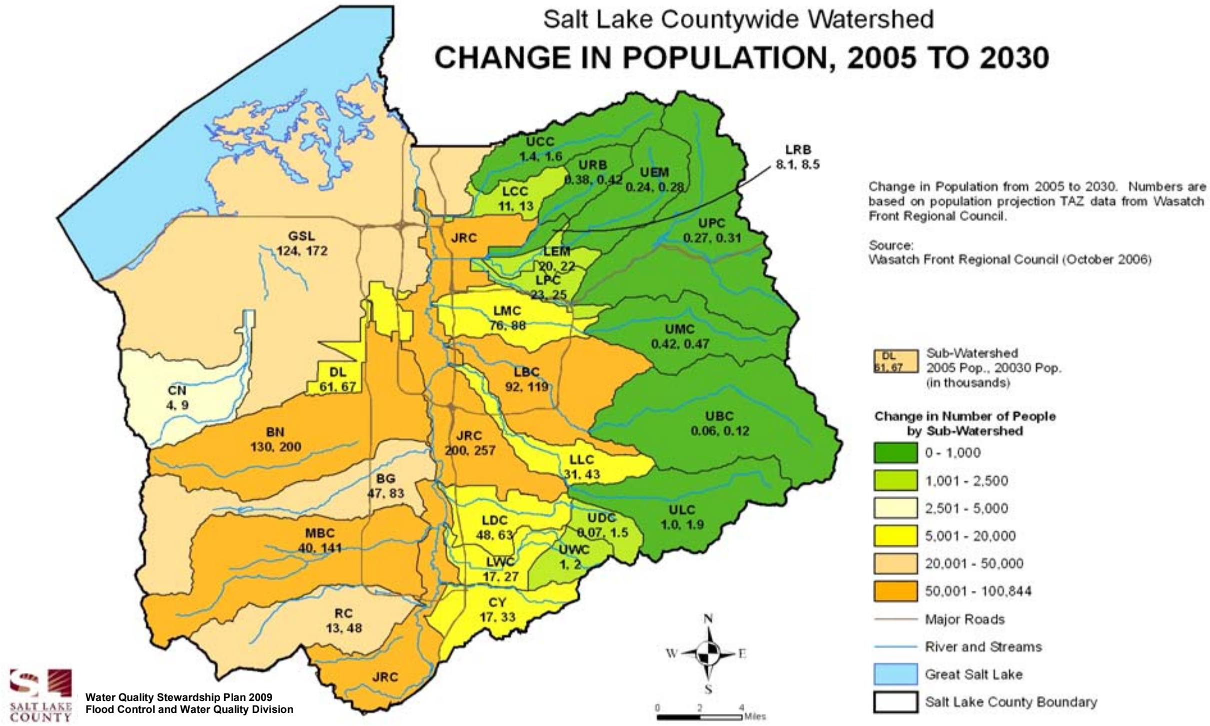


Figure 3.5.1 Change in Population 2005 to 2030

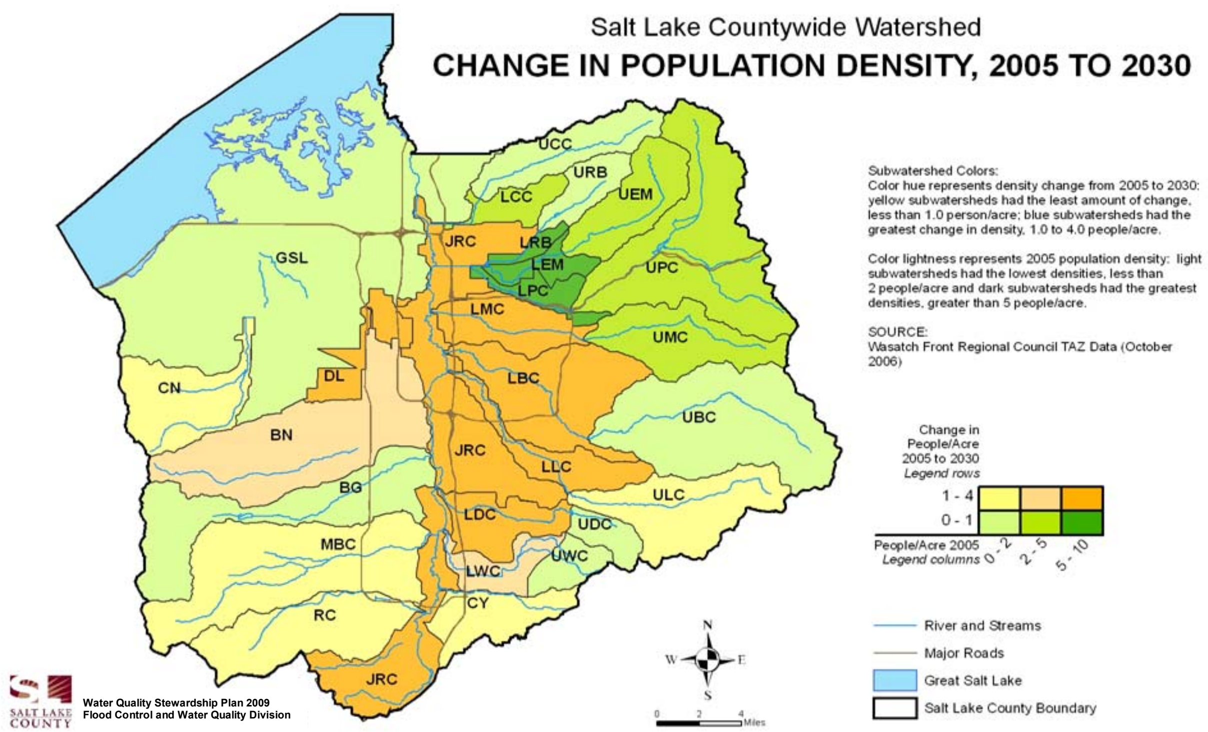


Figure 3.5.2 Population Density and Density Change

change in density were analyzed by sub-watershed (Figure 3.5.2). As with population, WFRC TAZ data and sub-watershed size are the foundation for this analysis.

Percent population change in the sub-watersheds of Salt Lake County is anticipated to vary between 4.8% (Lower Red Butte Creek Sub-Watershed) to 74% (Rose Creek Sub-Watershed). The areas that are anticipated to experience the highest percent change in population over the next 30 years are: Rose Creek (74.0%), Midas/Butterfield Creeks (71.8%), Upper Dry Creek (51.5%), Coon Creek (50.5%), and Corner Canyon Creek (49.5%) Sub-Watersheds (Table 3.5.2).


Lake Mary, Upper Big Cottonwood Creek Sub-Watershed

3.5.1.2 Upper Sub-Watershed Populations

The purpose of this section is to evaluate population figures and projections specific to the upper sub-watersheds, or canyon areas, where significant populations exist. These areas are currently not studied by WFRC. Although some year-round residences exist in the upper sub-watersheds of the Oquirrh Mountains, the majority of the canyon populations are in the Wasatch Mountains. Future development, population growth, and increased recreational use in the sensitive upper sub-watershed areas are important factors that may affect water quality.

Not all of the upper sub-watersheds in the Wasatch Mountains have urban development. Upper City Creek and Upper Red Butte Creek Sub-Watersheds do not have urban development (commercial or residential); whereas, Upper Emigration Creek Sub-Watershed has considerable residential development. In Upper Parley's Creek Sub-Watershed, tributary Mount Aire and Lambs Canyons have a small number of residential structures. The majority of these structures are for recreational or seasonal use. Upper Mill Creek Sub-Watershed has two restaurants and many recreation sites. The majority of residential development in Upper Mill Creek Sub-Watershed is located in Porter Fork; however, all but a few of the residential structures are on property leased from the U.S. Forest Service. Upper Big and Little Cottonwood Sub-Watersheds are highly developed areas with commercial, residential, and recreational development. Both of these sub-watersheds are dominated by mountain resort development; however, Upper Big Cottonwood Creek Sub-Watershed has the largest number of recorded subdivision lots and the largest amount of privately owned land (6,544 acres). With the exception of Upper Red Butte Creek Sub-Watershed, all the upper sub-watersheds are available for recreational use, generally occurring on U.S. Forest Service lands.

WFRC developed population estimate data for the Wasatch Mountains in 2005 based on building permit information. Those estimates are shown in Table 3.5.3. The populations in the canyons are relatively small compared to other areas of the County. As a result, WFRC has focused on the higher population areas in the valley areas of the County and has not prepared population projections past 2005 for the Wasatch Canyons. It is expected that the valley areas will experience the greatest amount of population growth over the next 30 years; however, population growth and development in the upper sub-watersheds could have a disproportional impact on water quality and supply in the County.

The Salt Lake County Assessor's Office developed the 2005 population estimates used in this analysis. This countywide database sets a value on all real properties in Salt Lake County. The database also identifies properties as: 1) improved residential lots (used year around), 2) recreational lots (used seasonally), or 3) undeveloped or vacant lots for the Wasatch Canyons. An undeveloped or vacant lot may or may not be developable based on compatibility of the lot with County requirements

Table 3.5.3 Year Round Population Forecasts for Wasatch Canyons

Wasatch Canyons Year Round Population				
Sub-Watershed	WFRC 2005	Assessor 2005	Build-out	Percent Change
Upper Big Cottonwood Creek	287	1,070	2,550	57.2
Upper City Creek	0	0	0	0.0
Upper Emigration Creek	1,218	1,330	3,365	60.5
Upper Little Cottonwood Creek	578	430	860	50.0
Upper Mill Creek	9	0	0	0.0
Upper Parley's Creek	6	25	1,255	98
Upper Red Butte Creek	0	0	0	0.0

Source: Salt Lake County Assessor, 2007

such as the FCOZ. Additionally, these lots are subject to the State of Utah, Salt Lake City, and Salt Lake County Health Department water regulations and culinary water supply requirements.

Table 3.5.4 shows the number of Improved Residential lots, Recreational lots, Undeveloped lots, and total lots (build-out) in the unincorporated areas of the upper Wasatch Mountain sub-watersheds.

Table 3.5.3 shows population forecasts used by Salt Lake County to estimate existing and future populations in the upper sub-watersheds. For this study, the County Assessor's Office estimated 2005 populations by multiplying the number of improved residential lots in the unincorporated area of the upper sub-watersheds by the average household size established by WFRC for TAZ units in the canyons (2.75 people per household).

In order to estimate the potential population at build-out in the upper sub-watersheds, the number of improved residential lots, recreational lots, and vacant or undeveloped lots were added and then multiplied by the average household size of 2.75. These build-out population forecasts are only an estimate. Some lots will likely be un-developable due to zoning constraints such as slope, stream setback, vehicular access, and water supply.

WFRC's estimates are similar to the estimate developed by the Assessor's Office with the

Table 3.5.4 Wasatch Canyon Residential Development

Wasatch Canyons Residential Development				
Sub-Watershed	Improved Residential Lots	Recreational Lots	Undeveloped Lots	Total Lots
Upper Big Cottonwood Creek	389	385	538	1,312
Upper City Creek	0	0	0	0
Upper Emigration Creek	485	23	605	1,113
Upper Little Cottonwood Creek	20	15	141	176
Upper Mill Creek	0	0	0	0
Upper Parley's Creek	25	162	349	1,649
Upper Red Butte Creek	0	0	0	0
Total for All Canyons				4,250

Source: Salt Lake County Assessor, 2007 exception of Upper Big Cottonwood Creek Sub–Watershed where WFRC estimates 287 residents and the County analysis estimates 1,070 residents (Table 3.5.3).

Another factor that may affect water quality is the number of seasonal lots in the upper sub-watersheds that may be converted to year round use, or how much undeveloped private acreage will be developed. This analysis was not conducted for this plan.

In addition to the residential populations in the upper sub-watersheds, there is a considerable amount of year-round use of these areas from timeshares, rental units, and recreation activities associated with the developed mountain resorts and camping areas. This analysis may be done in the future to more completely characterize potential effects from increased use of the upper sub-watersheds.

3.5.2 Land Use

Land use is an important factor contributing to existing and projected water quality conditions of surface waters. In reviewing existing and future land uses, development strategies may be evaluated and implemented to protect surface water quality.

WFRC collected and combined the adopted city land use plans to create the Salt Lake County Future Land Use GIS dataset. Although this dataset characterizes future land use, city general plans typically only project land use for 5 to 10 years. Therefore, target future dates can vary between cities. Consequently, this dataset is labeled “future” as opposed to a specific year. In addition to the WFRC future dataset, Stantec Consulting created an existing land use GIS dataset in 2000 by using city plans and aerial photographs. In this section, the WFRC and Stantec datasets have been analyzed as they relate to water quality.

The land use categories originally described by WFRC, the cities, and Stantec Consulting were not identical. Therefore, WFRC and Stantec Consulting land use categories were consolidated, combined and/or grouped to make these two datasets compatible. For example, areas categorized as commercial represent an agglomeration of commercial and mixed use areas identified by WFRC and Stantec (Table 3.5.5).

Existing land use and future land predictions can be seen in Figures 3.5.3 and 3.5.4. By comparing these two datasets, areas anticipated to change were identified. Commercial land uses are expected to expand along the I-15 corridor, and along all major transportation corridors throughout the county. Residential development is expected to expand along the Oquirrh Mountains, replacing agricultural, industrial, and open space land uses. Dominant land uses anticipated in 2030 include: Forest (39.3%), Residential (32.2%), and Parks/Agriculture/Open Space (6.7%). Land uses anticipated to comprise less total acreage in 2030 include: Industrial (6.6%), Public/Institutional (4.2%), Transportation (1.8%), Commercial (0.9%), and Other (0.2%).

3.5.2.1 Land Use – Impervious Surface Area

Imperviousness, or percent impervious surface area, is a measure of level of development and water infiltration capacity. For example, an aspen forest will allow for greater infiltration of water into the ground than a paved parking lot. Potential impacts of increasing the percent impervious surface area in a watershed include: 1) reduced groundwater recharge, 2) reduced groundwater storage capacity, 3) increased runoff into streams that may increase flood potential and erosion, and 4) increase in urban pollutants discharged to streams by stormwater runoff. With the expansion of urban development into previously undeveloped areas and increasing population densities, there is expected to be an increase in impervious surface area throughout the County. In this section, changes in impervious surface area are identified by analyzing existing and future land use datasets.

In order to calculate the total percent impervious surface area in a given sub-watershed, land use categories were assigned percent impervious surface area values (Table 3.5.6). These percent of impervious surface area values came from the U.S. Natural Resources Conservation Service’s *Technical Release 55, Urban Hydrology for Small Watersheds* (1986). By using the percentages outlined in the technical document, percent

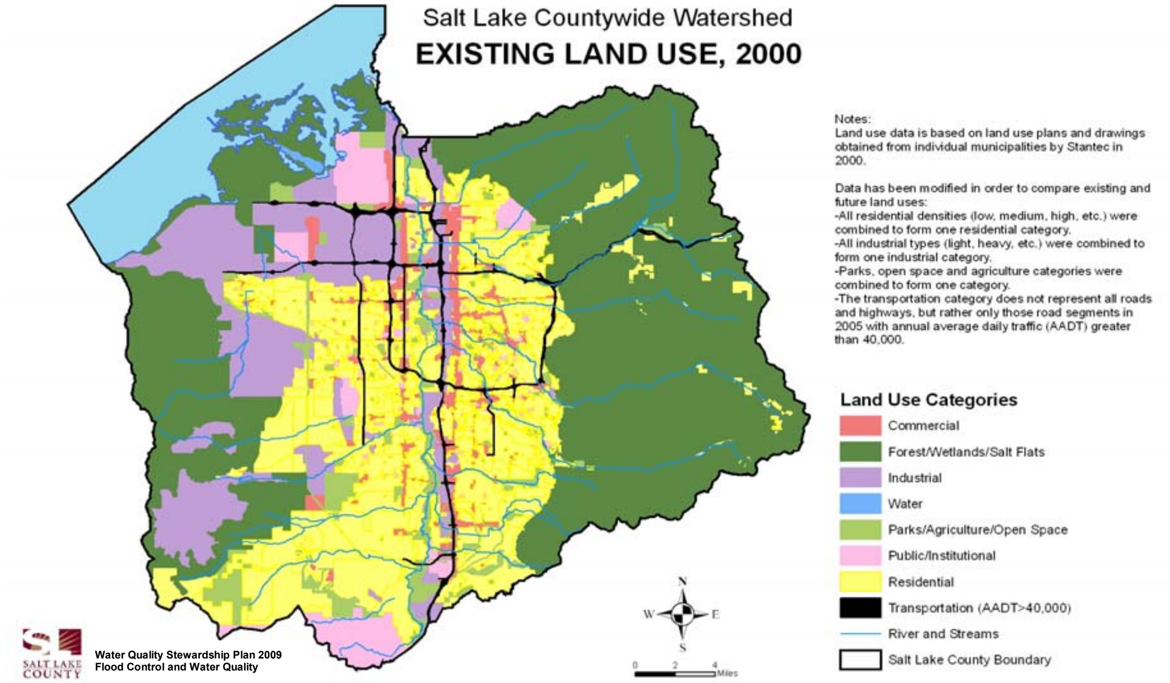


Figure 3.5.3 Existing Land Use

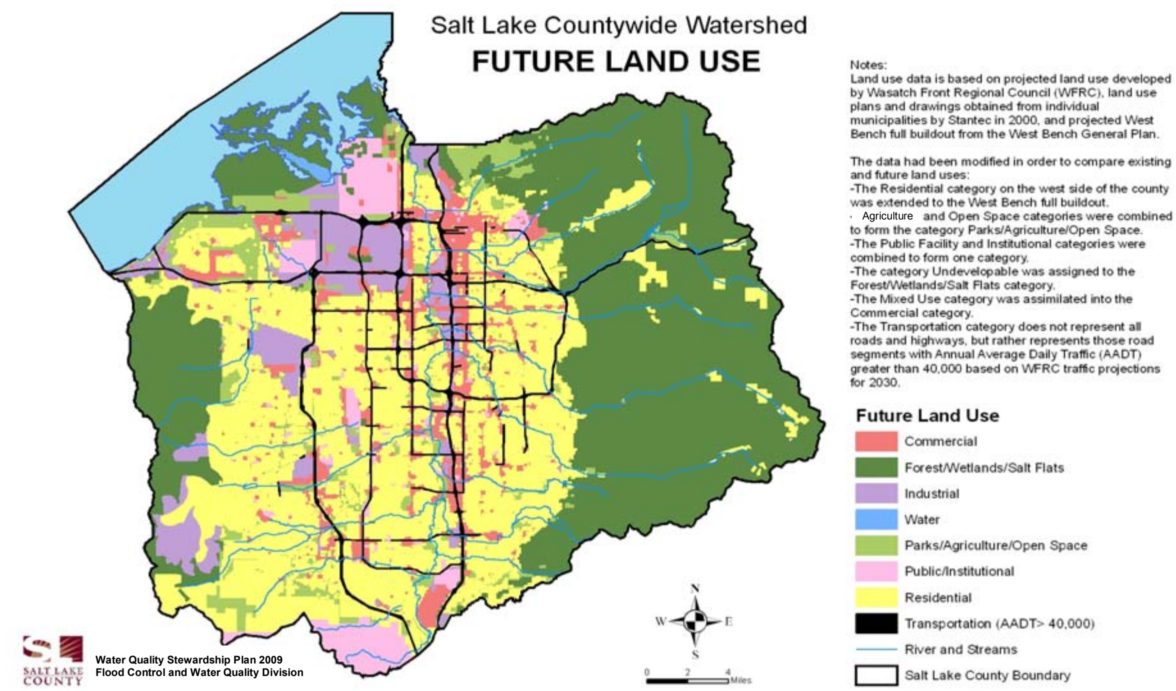


Figure 3.5.4 Future Land Use

Table 3.5.5 Land Use Category Grouping

Combined Land Use Category	Existing Land Use Category	WFRC Land Use Category
Commercial	Commercial Mixed Use	Commercial
Forest/Wetlands/Salt Flats (Environmentally Sensitive Areas)	Undevelopable	Mountain
Industrial	Industrial	Light Industrial Heavy Industrial
Water	Water	Lake
Residential	Residential	Low Residential Medium Residential High Residential
Parks/Agriculture/Open Space	Agriculture Open Space	Parks and Range
Public/Institutional	Public Facility Institutional	Public Utility
Transportation – all roads with an Annual Average Daily Traffic (ADDT) greater than 40,000 as published by UDOT	Transportation	Transportation

impervious surface area in each sub-watershed was determined by multiplying the number of acres for each land use category by the associated impervious value. A weighted average percent of impervious surface area was then calculated for each sub-watershed, for both existing and projected land uses. This weighted average was calculated for both existing and projected land uses. These values were then compared to derive a change in percent impervious surface area. Figures 3.5.5 and 3.5.6 show the sub-watersheds with the greatest amount of change in impervious surface area based on land use.

Analysis of land use and associated percent impervious surface area shows that there is expected to be a total increase of 3.7%, or 5,429 acres, of impervious lands throughout the County if existing land development practices continue. A 20.9% increase in the Midas/Butterfield Creek Sub-Watershed is anticipated to be the largest percent change. This is followed by Lower Emigration Creek (17.1%), Lower Mill Creek (14.7%), Jordan River Corridor (14.2%), Barney's Creek (11.7%) and Lower Parley's Creek (11.3%) Sub-Watersheds.

Six (6) sub-watersheds show a reduction in impervious surface area. Coon Creek Sub-Watershed had the largest reduction in the County (22.3%). This reduction in impervious surface area is due to the projected growth along the West Bench of the Oquirrh Mountains. This area currently has an industrial land use for mining activities. Future land use plans show a change from industrial land uses to open space/parks/agriculture and residential uses. Residential land use has about one-half the amount of imperviousness as compared to industrial land use (Table 3.5.6); however, mining activities may have a much lower percent of imperviousness than typical of industrial land use. Therefore, Coon Creek Sub-Watershed may not actually realize this percent reduction. Much of the new development is expected to happen beyond the 2030 timeframe; therefore, the biggest change in impervious surface area is anticipated to occur after 2030. Other sub-watersheds that are projected to see a reduction in

Table 3.5.6 Percent Impervious Surface Area Values Based on Land Use

Land Use	%Impervious
Public/Institutional	51%
Commercial & Transportation	85%
Industrial	72%
Residential	32%
Open Space/Ag/Parks	12%
ForestWetlands/Salt Flats	9%

Source: US Soil Conservation Service, 1986

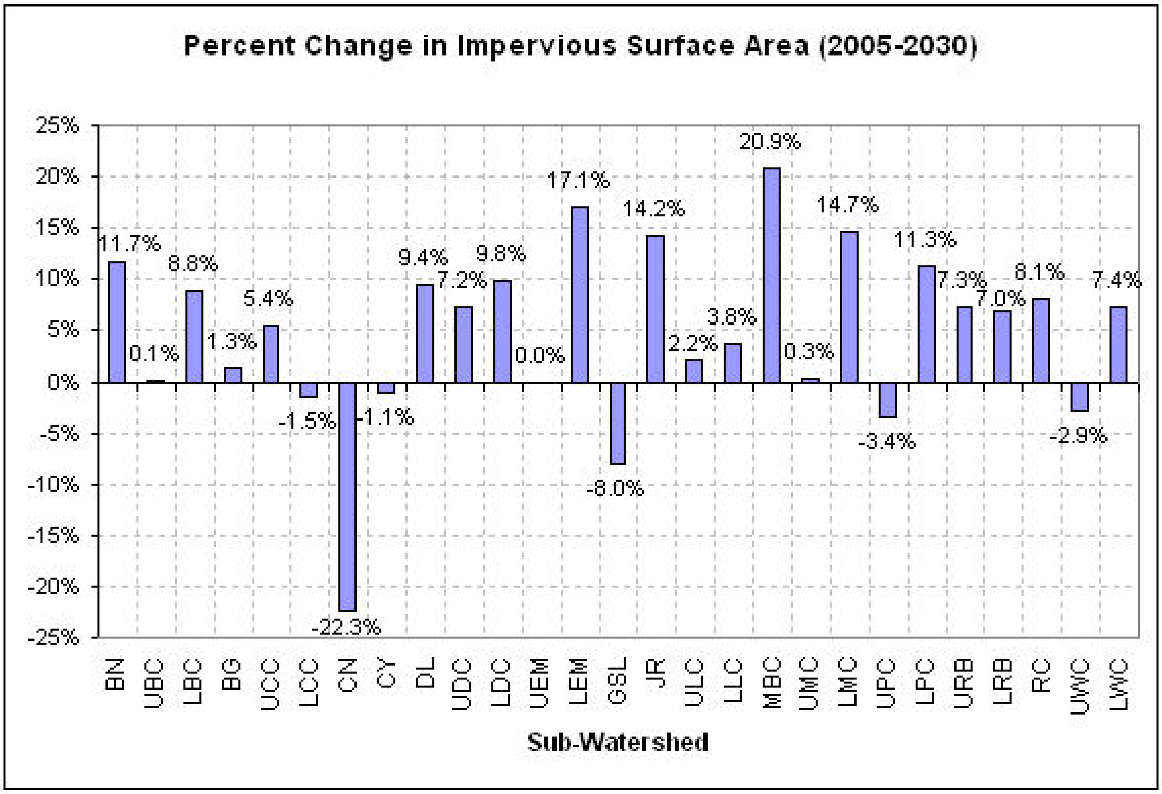


Figure 3.5.5 Change in Impervious Surface Area by Sub-watershed

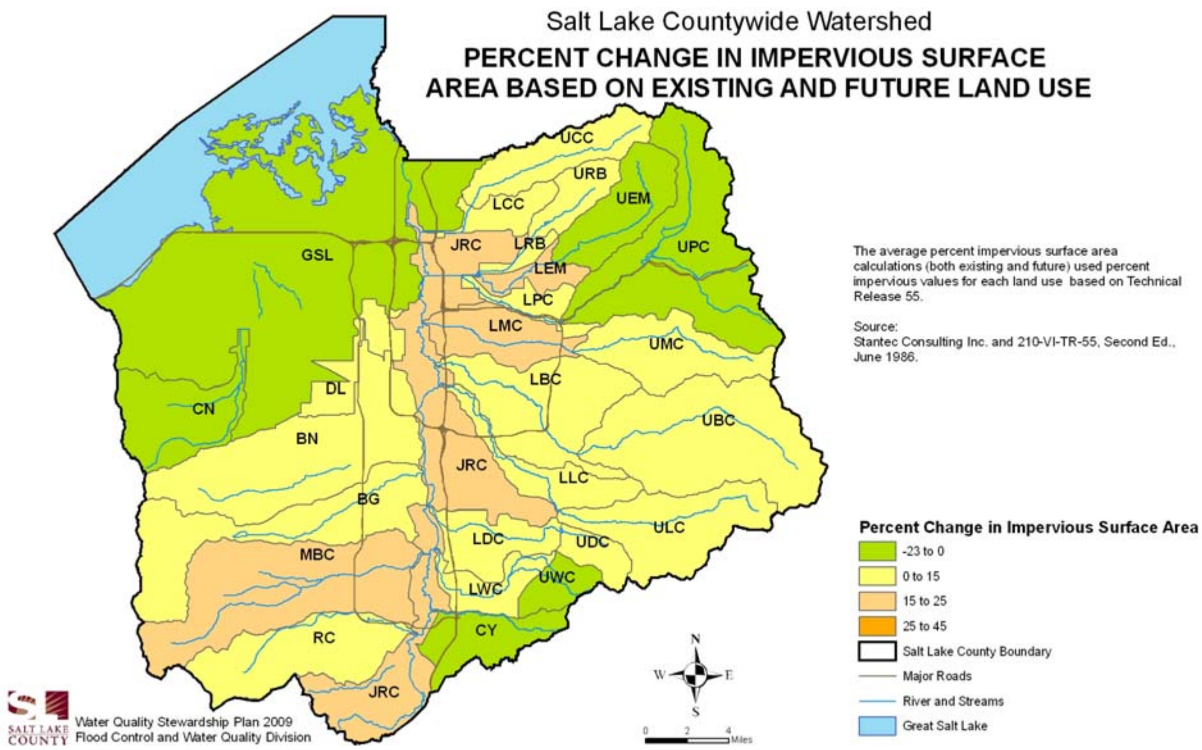


Figure 3.5.6 Anticipated Percent Change in Impervious Surface Area

impervious surface area are: Great Salt Lake (8%), Upper Parley's Creek (3.4%) and Upper Willow Creek (2.9%). Lower City Creek and Corner Canyon Creek are anticipated to experience 1.5% and 1.1% reductions in impervious surface area.

3.5.2.2 Land Use – Open Space

In addition to impervious surface area, the current and future land use datasets were used to project potential changes in open space in Salt Lake County. The open space in each sub-watershed was calculated by summing the forest/wetlands/salt flats and open space/agriculture/parks land use areas. This was done for both current and future land uses and was subsequently compared to determine percent change in open space per sub-watershed (Figures 3.5.7 and 3.5.8).

This analysis indicates that by 2030, 13,707 acres, or 6.0% open space that currently exists in Salt Lake County, will be developed. Sub-watersheds that are projected to have the greatest percent loss of open space include: Lower Mill Creek 66.0% (392 acres), Midas/Butterfield Creek 60.8% (6,327 acres), Decker Lake 54.0% (120 acres), and Barney's Creek 53.4% (4,603 acres).

According to this analysis, nine (9) sub-watersheds are anticipated to experience an increase in open space. Corner Canyon Creek is projected to increase by 23.8% (650 acres), Lower Red Butte Creek is projected to increase by 12.2% (58 acres), and Lower City Creek 7.2% (208 acres). Although some of this increase in open space is expected to result from open space designations and land set aside for recreational use, this apparent change may also result from discrepancies between the methodologies used to characterize existing and future land use.

3.5.2.3 Land Use - Land Cover

In October of 2005, the United States Geological Survey (USGS) (Lowry et al., 2005) published a report on their Southwest Regional Gap Analysis Project (GAP). This project represents a 5-year effort to map land cover (vegetation) in Arizona, Colorado, Nevada, New Mexico and Utah. The land cover data was generated using Landsat imagery and Digital Elevation Model (DEM) data that was ground-truthed over three (3) field seasons. The resulting data has a 30-meter resolution – meaning that each 30-meter square pixel was categorized in one land cover category. The GAP study identified 125 land cover categories in the Southwest Region of the United States, 40 of these categories were observed in Salt Lake County (Lowry et al., 2005).

Of the 40 land cover categories observed in Salt Lake County, nineteen (19) comprised less than 1% of the land area each. Countywide, the land cover categories, as defined by the GAP study, that comprised the largest area were Developed (16.5%) and Rocky Mountain Gambel Oak (14.0%). Table 3.5.7 describes the dominant land covers in the Valley, Wasatch Mountain, Traverse Mountain, and Oquirrh Mountain areas of the County.

Developed or Agriculture land covers overwhelmingly characterize the valley portion of Salt Lake County (Figure 3.5.9); however, the resolution of this data (30-meter resolution) does not capture small vegetation communities that border stream and river systems. These vegetation communities, although relatively small, may provide some of the most valuable habitat in Salt Lake County.

Less altered or developed land covers dominate the Wasatch Range. The most abundant land covers include: Rocky Mountain Gambel Oak, Rocky Mountain Aspen Forest, and Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland. These land covers contain vegetation species such as Gambel Oak, Serviceberry, Sagebrush, Chokecherry, and Quaking Aspen, which provide valuable habitat. Barren and sparsely vegetated land covers, such as exposed rock, categorized as Rocky Mountain Alpine Bedrock/

Riparian Vegetation in Lambs Canyon, Upper Parley's Creek Sub-Watershed

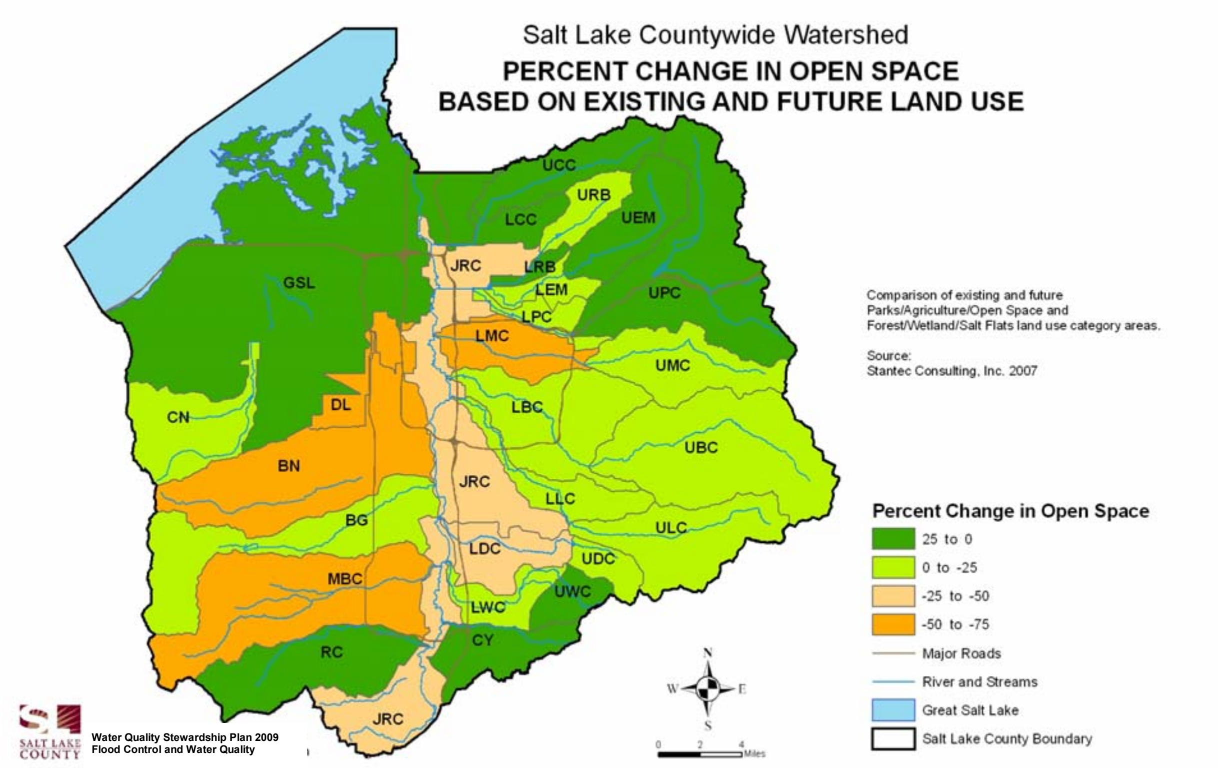


Figure 3.5.7 Anticipated Percent Change in Open Space

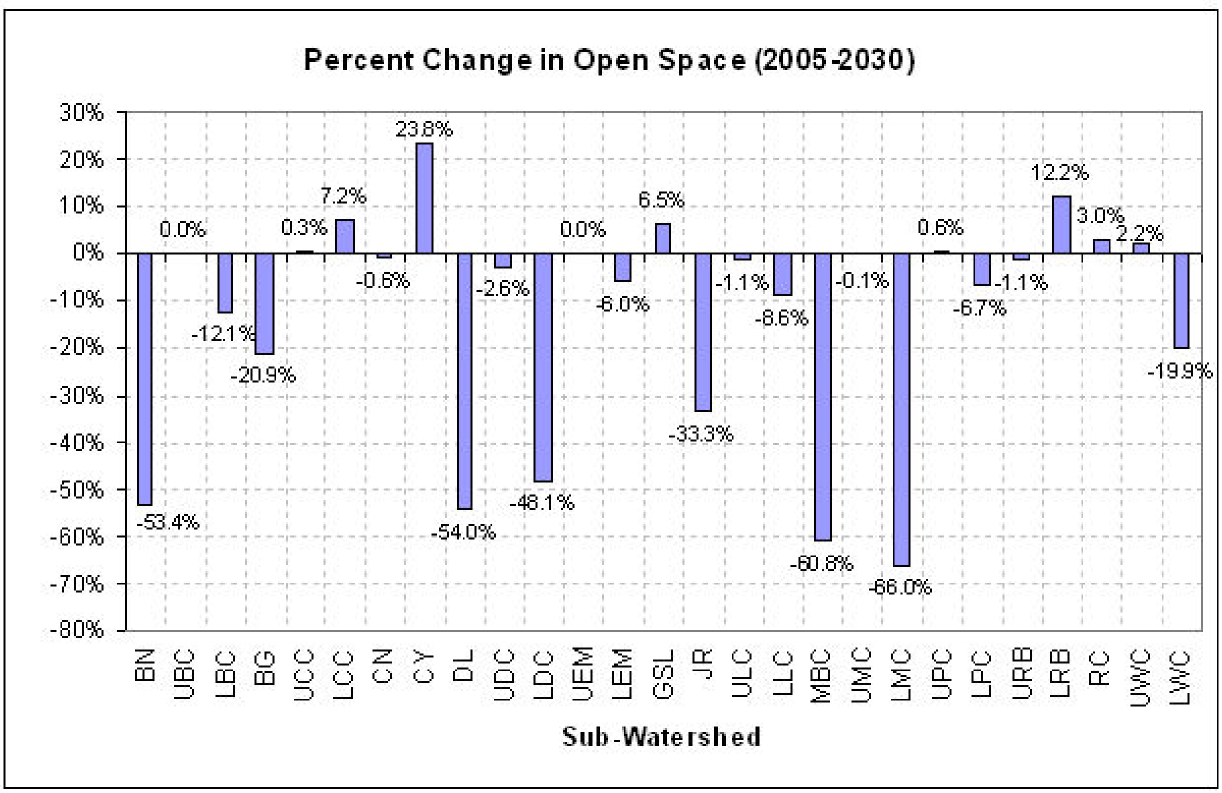


Figure 3.5.8 Change in Open Space by Sub-Watershed

Table 3.5.7 Dominant Land Cover in Salt Lake County

Area	Dominant Land Cover	Description
Oquirrh Mountains	Rocky Mountain Gambel Oak – Mixed Montane Shrubland	Gambel Oak, Serviceberry, Sagebrush, Chokecherry, Bitterbrush, Locust, Snowberry
	Inter-Mountain Basins Big Sagebrush Shrubland	Sagebrush, scattered Juniper, Greasewood
	Rocky Mountain Aspen Forest and Woodland	Quaking Aspen, Conifer component > 25%, with graminoids and forbs
	Inter-Mountain Basins Montane Sagebrush Steppe	Mountain sagebrush and related taxa. Bitterbrush may co-dominate
Traverse Mountains	Rocky Mountain Alpine Bedrock and Scree	Barren and sparsely vegetated alpine substrates, typically including both bedrock outcrop and scree slopes, with nonvascular- (lichen) dominated communities
	Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland	High-elevation system, dominated by Engelmann Spruce and Subalpine Fir
Valley	Developed, Medium – High Intensity	Impervious surfaces 50% – 79% Highly developed areas where people reside or work
	Developed, Open Space – Low Intensity	Lawn Grasses Impervious surfaces < 20% Parks, golf courses and vegetation planted for recreation, erosion control, or aesthetics
	Agriculture	Land under cultivation
Wasatch Mountains	Rocky Mountain Gambel Oak – Mixed Montane Shrubland	Gambel Oak, Serviceberry, Sagebrush, Chokecherry, Bitterbrush, Locust, Snowberry
	Rocky Mountain Aspen Forest and Woodland	Quaking Aspen, Conifer component > 25%, with graminoids and forbs
	Rocky Mountain Montane Mesic Mixed Conifer Forest & Woodland	Douglas Fir and White Fir are most common canopy dominants, but Engelmann Spruce, Blue Spruce, or Ponderosa Pines may be present. This system includes mixed conifer/quaking aspen stands

Source: Lowry et. al., 2005

Scree and Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland dominate the Traverse Mountain Range. The Oquirrh Mountains contain land covers similar to those found in the Wasatch Mountains. However, this area has extensive mining practices that have altered the pre-existing land covers.

Residential Neighborhood Along East Bench of Salt Lake County

Overall, the land cover categories identified by the USGS in Salt Lake County are typical of the basin range region of the western United States. Conifers such as spruce, pines, and firs are typically found among oaks, quaking aspen and juniper trees in the mountains of the arid west; whereas, sagebrush and other drought tolerant species dominate undeveloped lands in the valley sections.

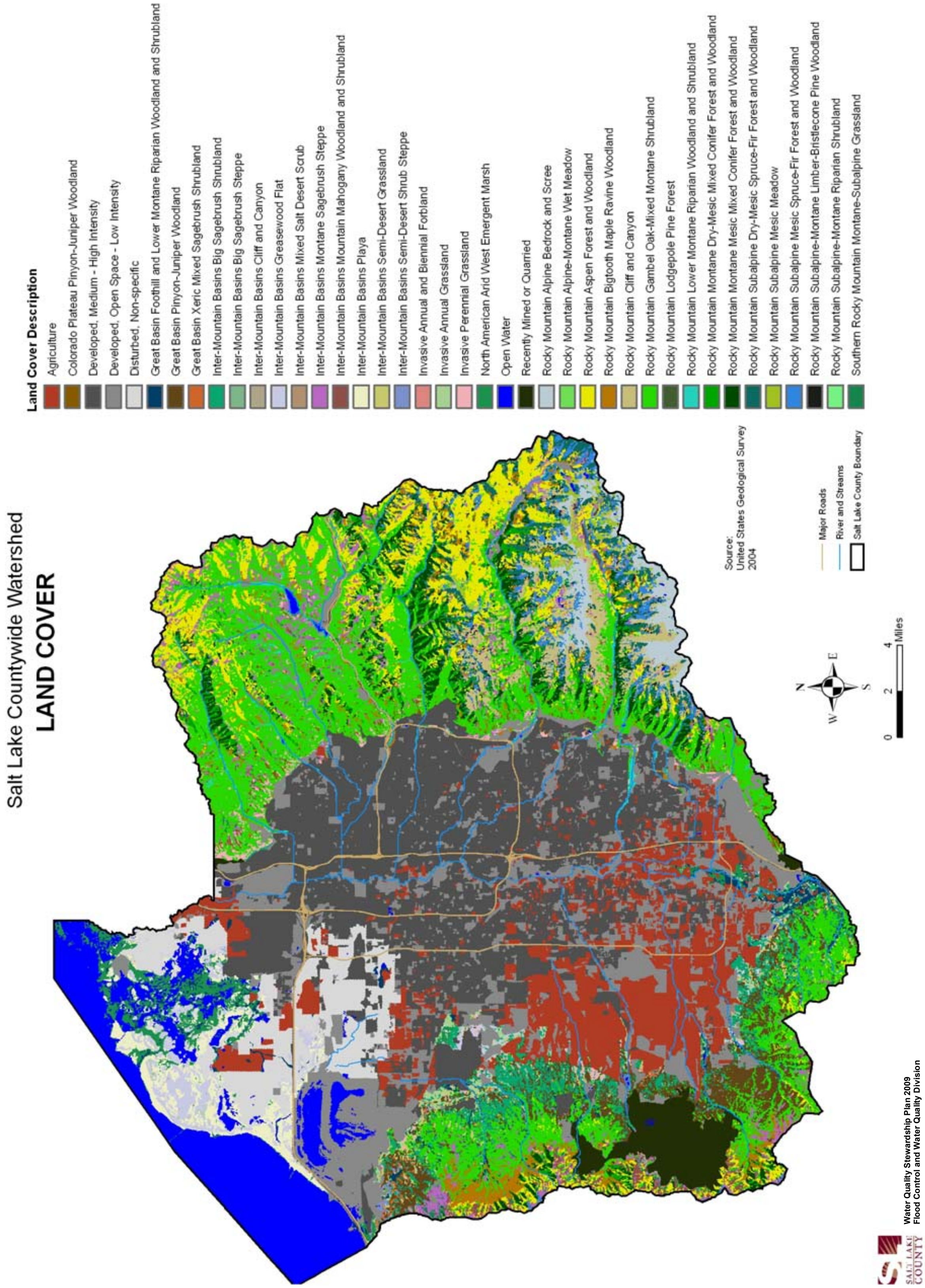


Figure 3.5.9 Land Cover

3.6 SOCIAL AND RECREATION

Salt Lake County is a world-class recreational destination as manifested by the hosting of the 2002 Winter Olympics. Major outdoor recreational opportunities in the mountain areas of Salt Lake County include: mountain resort skiing and snowboarding, hiking, camping, rock climbing, picnicking, cross country and backcountry skiing, wildlife observation, hunting, and bicycling. Outdoor recreational opportunities in the valley areas of Salt Lake County are concentrated at developed parks, golf courses, trails and open spaces (Figure 3.6.1).

Winter recreational opportunities are scattered throughout the County, but are heavily concentrated in the Wasatch Mountains. There are four (4) major ski resorts (Alta, Snowbird, Brighton, and Solitude) in the Wasatch Mountains within Salt Lake County; no developed mountain resorts exist in the Oquirrh Mountains. Wasatch Mountain resorts provide significant tourist draw to this area. Ski Utah, a “marketing company owned and operated by the Utah Ski and Snowboard Association” estimates that in 2006, Utah had slightly over 4 million skier visits (Demographic and Economic Analysis Section, 2006). This represents approximately 7% of the ski industry market share in the United States. Of the ski resorts in Salt Lake County, Alta received the most visitors in the 2005-2006 winter season with 498,800 skier visits, followed by Snowbird (478,400), Brighton (429,800) and Solitude (201,200). This data suggests Upper Little Cottonwood Sub-Watershed receives 30% more visitors than Upper Big Cottonwood Sub-Watershed during the winter months. Additional data provided by the Salt Lake City Ranger District (SLCRD) shows that ski area visitation remained relatively stable between 1995 and 2007, ranging between 1.2 and 1.6 million visitor days per year. This data also shows that Alta and Snowbird are consistently the most visited resorts (Table 3.6.1).

In addition to winter recreational opportunities in the Wasatch Mountains, hiking, mountain biking, rock climbing are all common summer activities in the mountain areas of the County. Although recent assessments of mountain recreational use have not been conducted, a major cooperative planning effort for the Wasatch Canyons was completed in 1989: *Wasatch Canyons Master Plan* (WCMP) (Salt Lake County, 1989). As part of the WCMP effort, analysis was done of recreational use in the canyons.

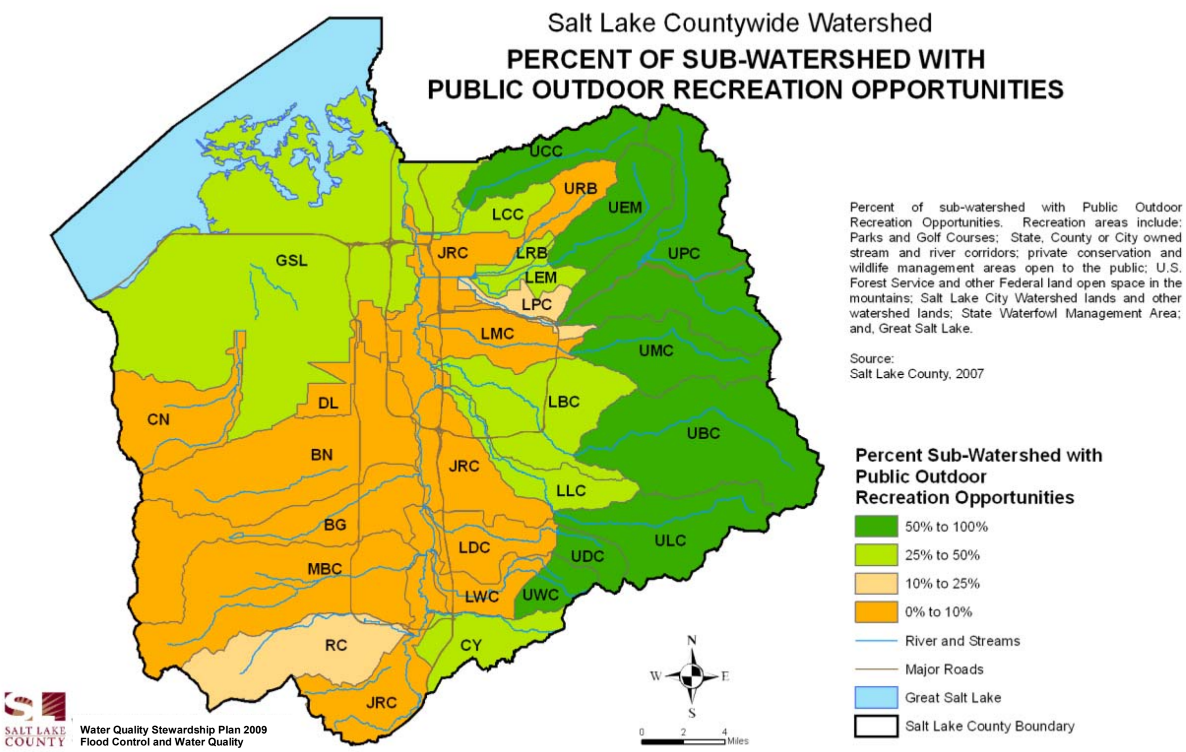


Figure 3.6.1 Public Outdoor Recreation Opportunities

Table 3.6.1 Ski Area Visitation in the Wasatch Mountains of Salt Lake County

Year	Alta	Snowbird	Brighton	Solitude	Totals
2006/07	528,923	468,793	386,804	194,966	1,579,486
2005/06	498,783	478,375	429,782	201,228	1,608,168
2004/05	480,426	516,919	391,979	184,567	1,573,891
2003/04	401,525	452,244	355,232	156,575	1,368,576
2002/03	380,998	416,000	335,494	137,952	1,270,444
2001/02	338,169	393,100	356,087	138,104	1,225,460
2000/01	369,293	426,866	342,064	186,660	1,324,883
1999/00	382,064	393,100	337,072	175,251	1,287,487
1998/99	409,162	381,999	354,270	201,092	1,346,523
1997/98	422,055	396,584	352,943	193,174	1,364,756
1996/97	453,268	384,289	356,969	215,832	1,410,358
1995/96	477,797	354,498	338,519	208,664	1,379,478
1994/95	513,897	360,305	370,828	242,227	1,487,257
Totals	**5,656,360**	**5,423,072**	**4,708,043**	**2,439,292**	**18,226,767**
Average	**435,105**	**417,159**	**362,157**	**187,638**	**1,402,059**

Source: Salt Lake Ranger District, 2008

Alpine skiing was identified as the largest recreational use of the canyons between 1986 and 1987 in WCMP, with 1.3 million skier visits. This translates to 650,000 Recreation Visitor Days (RVD). An RVD represents one 12-hour visit or twelve 1-hour visits. The second highest recreational use of the Wasatch Canyons in the WCMP study was picknicking with approximately 160,000 RVDs in 1987. Hiking showed 140,000 RVDs, camping had 125,000 RVDs, cross-country skiing 60,000 RVDs, snowmobiling 15,000 RVDs and hunting 13,000 RVDs. The WCMP data may be used as a general guide to determine relative frequencies of RVDs in the various recreational activities.

Outdoor valley recreational opportunities are available through both city and county parks, golf courses, and trails systems.

There are currently 465 public parks (29,065 acres) in Salt Lake County. Publicly managed parks are typically divided into the following categories: community, neighborhood, regional, special use, open lands, state parks and the zoo. In Salt Lake County, the majority of identified parks (267, 57% of all parks) are categorized as neighborhood parks. Neighborhood parks are defined as small facilities that serve the community living within a 1-mile radius of the park. Table 3.6.2 shows the ownership and size of parks throughout the County. Salt Lake City (125 parks) and Salt Lake County (98 parks) continue to provide the majority (48%) of developed park recreational opportunities. However, numerous municipalities in the western and southwestern portions of the County are incorporating community parks into their overall planning efforts. In total, 29,065 acres of parkland exists (5.6% of land in the County) in Salt Lake County.

In addition to parks, there are 30 publicly owned golf courses in Salt Lake County. Private courses exist; however, information was not available for

Table 3.6.2 Salt Lake County Parks Inventory

Owner	Number	Acres	Square Miles
Draper City	31	1,005	1.6
Herriman City	8	132	0.2
Home Owners Associations (HOAs)	5	9	0.0
LDS Church	2	16	0.0
Midvale City	2	18	0.0
Murray City	20	374	0.6
Private	23	1,047	1.6
Recreation District	1	35	0.1
Riverton City	24	174	0.3
Salt Lake City	125	18,663	29.2
Salt Lake County	98	4,502	7.0
Sandy City	29	526	0.8
South Jordan City	16	320	0.5
South Salt Lake City	1	9	0.0
Special Service District	2	47	0.1
State of Utah	5	671	1.1
Taylorsville City	3	15	0.0
Utah Nonprofit Housing Corp	1	2	0.0
West Jordan City	41	520	0.8
West Valley City	28	978	1.5
Total	**465**	**29,065**	**45.41**

Source: Salt Lake County, 2007

these facilities and they are not included in this analysis. According to the Salt Lake County Parks and Recreation Division, annual use of city and county golf courses varied between approximately 12,000 and 78,000 rounds played per course in 2006 (Unpublished Data; City vs County Rounds and Revenue). In 2006, the most heavily used of these facilities were Riverbend, Meadowbrook, and Bonneville golf courses.

Trail systems have also been developed throughout Salt Lake County. The Jordan River Parkway represents a "multi-jurisdictional effort to accommodate recreational use of the Jordan River corridor" (Salt Lake County, 2007). The trail is generally a paved system that runs adjacent to the Jordan River for over forty (40) miles. Additionally, there are 45 trailheads in the Parkway system. Although several sections of the trail are well-developed and used, there are eight (8) gaps in the trail system. Currently, the Salt Lake County Parks and Recreation Division is developing a master plan for the Jordan River Parkway that will examine opportunities for connecting the trail where it is fragmented.


Ensign Peak Trail, Lower City Creek Sub-Watershed

Although this trail primarily supports pedestrian and cycling uses, there are adjacent equestrian dirt paths throughout the majority of the Parkway system. Recently, several sections of the Jordan River Parkway trail have been jeopardized due to bank erosion from high flows of the Jordan River. Significantly, trails are not categorized as "structures" and are subsequently allowed in the meander corridor. The Jordan River Parkway Trail is a top priority and concern of local residents and adjacent municipalities.

Jordan River Parkway Trail, Jordan River Corridor Watershed

The Bonneville Shoreline Trail runs along the ancient Lake Bonneville shoreline in the foothills of the Wasatch and Oquirrh Mountains. At completion, the trail will be over 90 miles in length – running from Utah County through Salt Lake and Davis Counties. Currently, the paved and unpaved trail is strictly for non-motorized use and supports pedestrian and bicycle uses.

In addition to the Jordan River Parkway and the Bonneville Shoreline Trails, there are over 17 miles of paved trails in the County. Additionally, the United States Forest Service (USFS) manages 176 miles of dirt trails in the mountains. The majority (72%) of USFS trails are for hiker/pedestrian use only. Bicycle use is allowed on 26% of the USFS trails, and only 3% of these trails allow all terrain vehicle use. There are 200 miles of trails in the Wasatch Mountains that are not managed by WCNF.

Recreation in the Great Salt Lake shorelands area in Salt Lake County is dominated by bird watching and hunting. Twelve (12) private duck clubs are located adjacent to the Great Salt Lake that are organized into the Southshore Wetlands and Wildlife Management group. Waterfowl observation opportunities exist at several protected areas along the shorelands, including: Farmington Bay Waterfowl Management Area, managed by the Utah Division of Wildlife Resources; Lee Creek Area of the South Shore Preserve, owned and managed by the National Audubon Society; and Inland Sea Shorebird Reserve, owned and managed by Kennecott Utah Copper.

Other water related outdoor recreational activities include canoe and kayak opportunities on the Jordan River as well as sailing on the Great Salt Lake. Several unimproved launch sites exist along the Jordan River Parkway Trail; however, it is uncertain whether these facilities are adequate for water trail use of the River. The current Jordan River Trails Master Plan will examine the water-based use of the Jordan River and assess if existing facilities meet the necessary demands of the system. The Antelope Island Marina and Saltair have launch facilities for kayaking and sailing in the Great Salt Lake. However, none of the streams, river or mountain lakes in Salt Lake County are classified as 2A (primary contact recreation) by the State Division of Water Quality (DWQ). The Great Salt Lake is the only surface water protected for swimming or contact recreation in Salt Lake County.

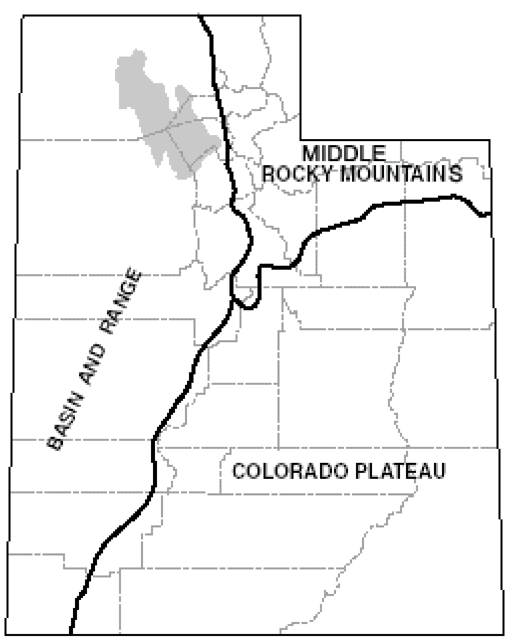
3.7 GEOLOGY AND SOIL

Salt Lake County is in the physiographic provinces of the Basin and Range and the Wasatch portion of the Middle Rocky Mountains Province. The Basin and Range Province extends across western Utah and contains "steep, narrow, north-trending mountain ranges separated by wide, flat, sediment-filled valleys" (UGS, 2007). This range formed when the previously deformed Precambrian and Paleozoic (570 to 240 million years old) rocks were uplifted and broken into fault blocks by extensional stresses. Notably, these stresses continue to stretch the earth's crust in this region and cause frequent, minor earthquakes.

In contrast to the Basin and Range province, the Middle Rocky Mountain province contains high mountains carved by streams and glaciers. Both the Wasatch and the Uinta Mountain ranges are found in this province; significantly, the Uinta Mountains are one of the few east-west-trending ranges in North America. Both the Wasatch and the Uinta ranges have cores of Precambrian rocks, some over 2.6 billion years old, that have been altered by multiple cycles of mountain building and burial.

Mountains in Salt Lake County are composed of rocks that range in age from Precambrian to Tertiary. The Wasatch range consists of Precambrian, Paleozoic, Mesozoic and Cenozoic (all period/ages of the earth) sedimentary rocks that have been intruded by tertiary granitic and dioritic stocks. The Oquirrh mountains on the west side of the County consist of Paleozoic sedimentary rocks, and intrusive and extrusive Cenozoic rocks. The Traverse Mountains on the south end of the County are composed of Paleozoic sedimentary and Cenozoic volcanic rocks.

The Wasatch Range began uplifting approximately 12 to 17 million years ago. "However, during the Cretaceous Period (138 to 66 million years ago), compressional forces in the earth's crust began to form mountains by stacking or thrusting up large sheets of rock in an area that included what is now the northeasternmost part of Utah, including the northern Wasatch Range. This thrust belt was then heavily eroded. About 38 to 24 million years ago large bodies of magma intruded parts of what is now the Wasatch Range. These granitic intrusions, eroded thrust sheets, and the older sedimentary rocks form the uplifted Wasatch Range as it is seen today" (UGS, 2007). The Uinta Mountains were first uplifted approximately 60 to 65 million years ago when compressional forces created a buckle in the earth's crust, called an anticline.



Physiographic provinces in Utah

The Salt Lake Valley is a graben bounded by faults on its east, west, and south sides. During the Tertiary and Quaternary, Lake Bonneville water covered the valley. The offshore valley was deposited with silts and clay mostly in the central parts of the valley. During Lake Bonneville 'dry' periods, sediments were deposited primarily as alluvial fans at the canyon mouths and as fluvial-channel and floodplain sediments in the central parts of the valley.

3.7.1 Surficial Geology

Surficial geology in Salt Lake County is best described in the context of Lake Bonneville, a freshwater lake that covered much of northern Utah approximately 15,000 years ago. Layers of basin-fill (up to 4,000 feet thick) material currently dominate the Salt Lake Valley (Figure 3.7.1). This material is a result of alluvial fans, stream channels, deltas, and lake cycle features all associated with Lake Bonneville. Most of these depositional features are tertiary-aged (up to approximately 1.65 million years ago) and semi-consolidated to consolidated. Alluvial fans are the most abundant of these depositional features. Lake Bonneville deposited clay layers occur throughout the valley, except near the mountain fronts where coarser-grained deposits exist. Finally, generally unconsolidated sediments of quaternary age material that is more permeable overlie these deposits. The Quaternary deposits range from less than 200 feet thick along the margins of the valley to more than 1,000 feet thick in the northern part of the valley (Hely et al., 1971).

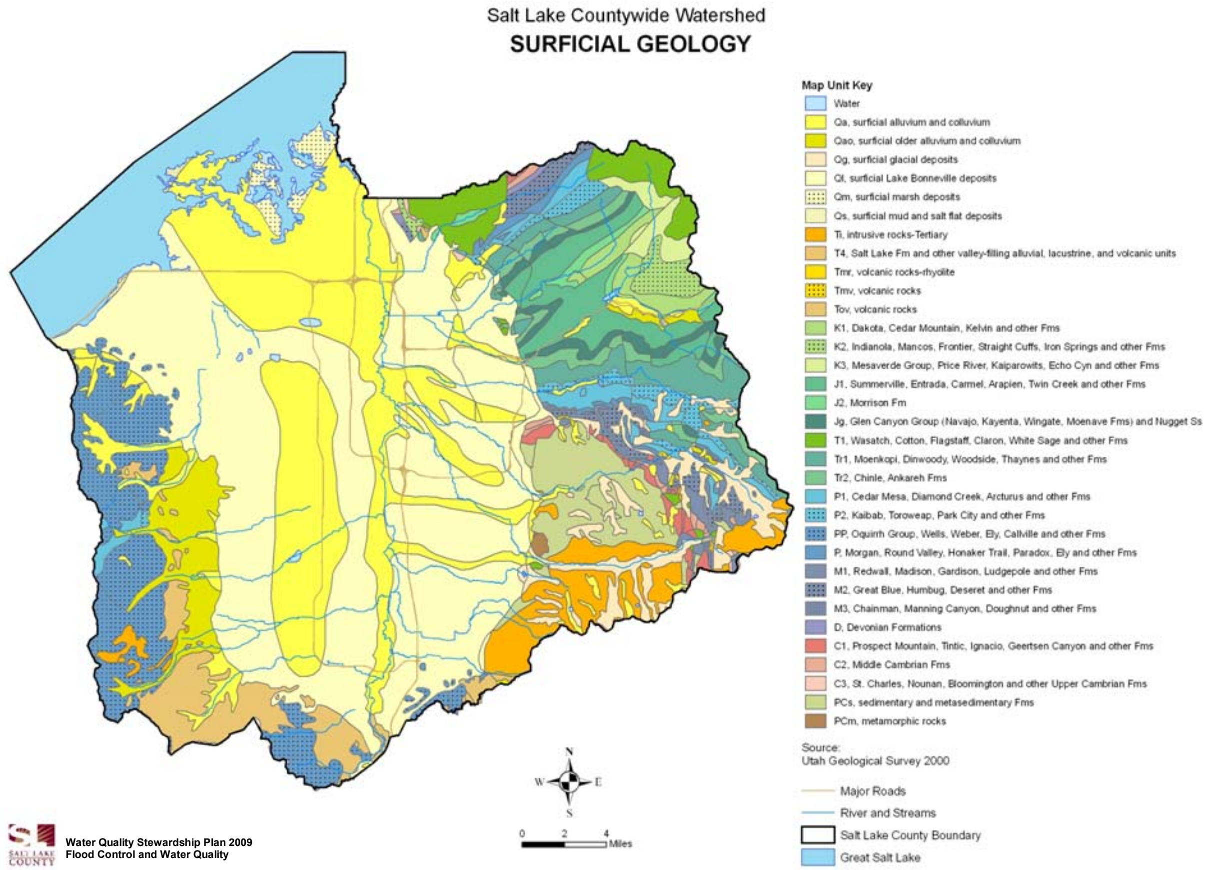


Figure 3.7.1 Surficial Geology

3.7.2 Soil Erosion

Soil erosion is a natural process in watersheds that involves the movement of soil resulting from wind, water or ice. A certain amount of erosion is healthy for the ecosystem; however, excessive erosion can be detrimental, as it results in loss of soil from the landscape and sedimentation in receiving waters. Excessive erosion can result from poor land management practices that allow deforestation, overgrazing, agriculture and construction activities. Many factors contribute to the rate of erosion, including precipitation intensity, soil texture and erodibility, land slope, land cover, and land management practices.

The Natural Resources Conservation Service (NRCS) mapped the soils in Salt Lake County and developed an erosion hazard rating for each soil type (NRCS, 1974 and 2002). The rating presented in this section is the "hazard of off-road or off-trail erosion" as described in the National Forestry Handbook (NRCS, 2004). The erosion hazard rating is based on the slope and soil erodibility K-factor of a surface that has 50 to 75 percent of its area exposed by logging, grazing, mining, or other kinds of disturbance. The hazard categories are described in Table 3.7.1.

Figure 3.7.2 shows the erosion hazard ratings for the soils in the watershed. The percentage of area rated as severe or very severe erosion hazard for each sub-watershed is shown in Figure 3.7.3. Generally, the sub-watersheds with the highest erosion potential are found in the Wasatch Mountains (e.g. Red Butte Creek, Emigration Creek, Parley's Creek, and Mill Creek). Additionally, the Coon Creek Sub-Watershed was found to have high erosion hazard potential. The sub-watersheds in the valley portion of the County typically showed low erosion hazard potential.

3.7.3 Landslides

Landslides are common natural hazards in northern Utah. Common types of landslides in Utah are

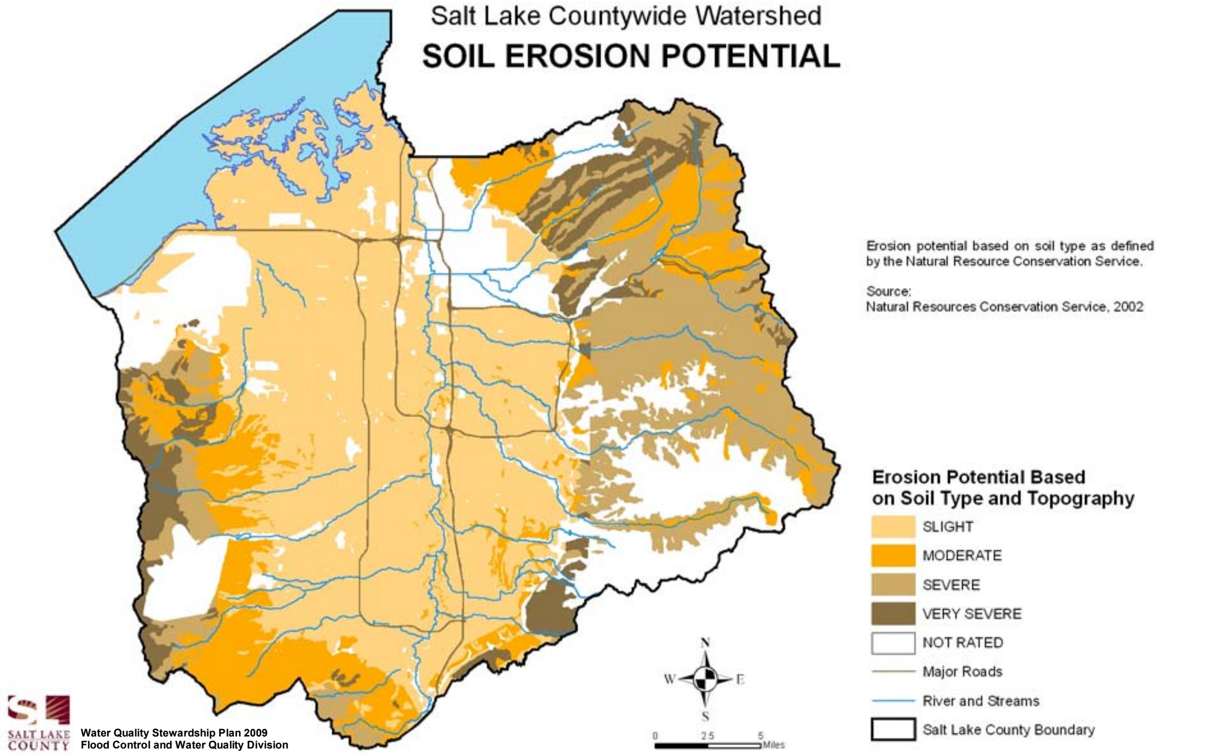


Figure 3.7.2 Soil Erosion Potential

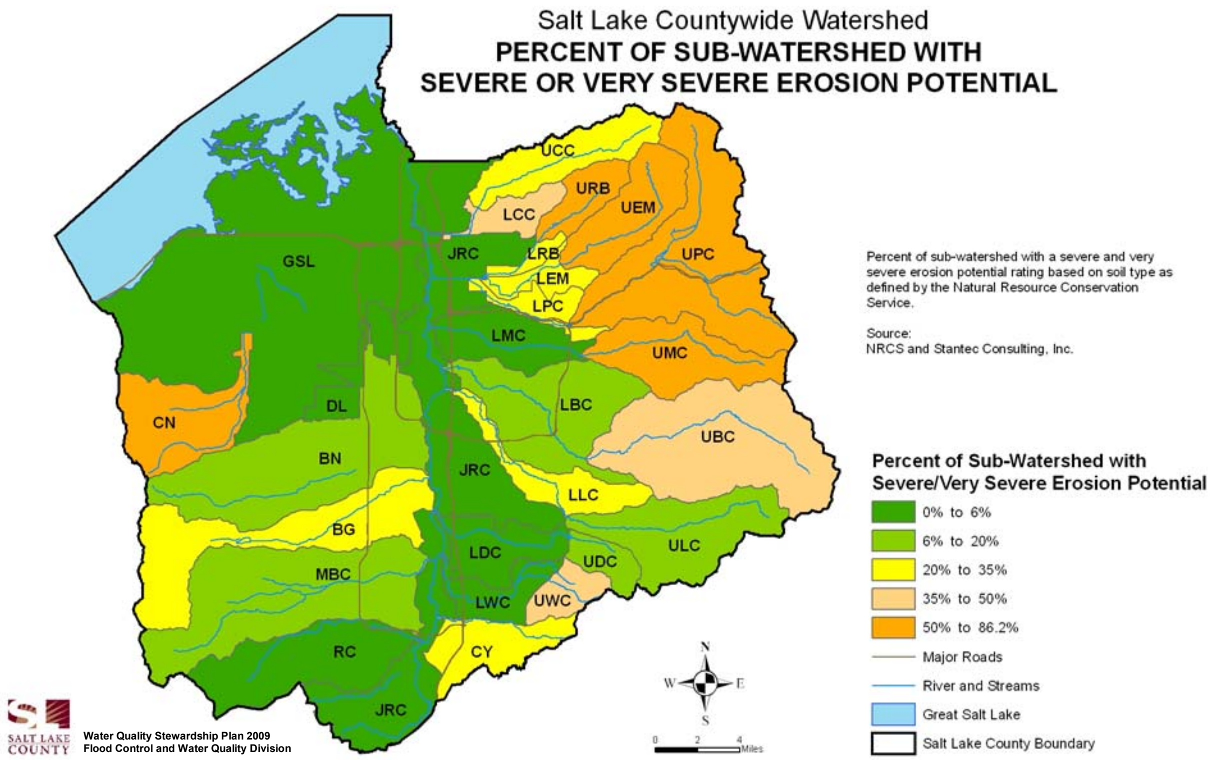


Figure 3.7.3 Percent of Sub-Watershed with Severe and Very Severe Erosion Potential

debris flows, slides, and rock falls. Debris flows consist of sediment-water mixtures that flow down a streambed or hillslope, commonly depositing sediment as alluvial fans at canyon mouths; slides are downslope movements of soil or rock; and rock falls consist of rock(s) falling from a cliff or cut slope.

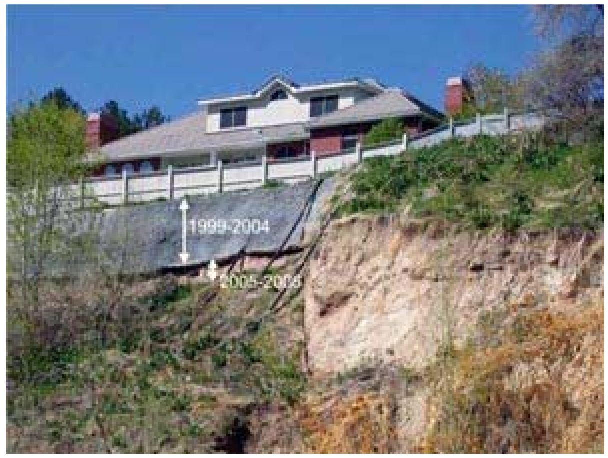
Many landslides are associated with rising groundwater levels resulting from heavy rainfall, rapid snowmelt, and/or addition of water to a slope from landscape irrigation, roof downspouts, poor drainage, septic-tank effluent, canal leakage, or broken water or sewer lines. Landslides in Utah typically occur during the months of March, April, and May, although debris flows associated with rainfall from intense thunderstorms are common in July.

Certain areas within Salt Lake County have historically experienced landslides and mass wasting such as debris flows or rock falls. These and other areas are susceptible to potential future landslides, as well. The Salt Lake County Division of Planning and Development Services conducted a special study to map landslides, debris flow and rock falls within the County (available from the web site the Salt Lake County Planning and Development Services website). The landslides map is a compilation of other studies and mapping efforts. The map shows many areas of debris flow and alluvial fan deposits along the benches of the Oquirrh Mountains and southeastern Wasatch Mountains. In addition, historical areas of rock slides and landslides are shown along the benches and within the canyons of the Wasatch Mountains.

Table 3.7.1 Erosion Hazard Descriptions from National Forestry Handbook

Erosion Hazard	Description
Slight	Erosion is unlikely under ordinary climatic conditions
Moderate	Some erosion is likely and that erosion-control measures may be needed
Severe	Erosion is very likely and that erosion-control measures, including re-vegetation of bare areas, are advised
Very Severe	Significant erosion is expected, loss of soil productivity and off-site damage are likely, and erosion-control measures are costly and generally impractical

Source: NRCS, 2004



City Creek Landslide, Lower City Creek Sub-Watershed

Per the Geologic Hazards Ordinance (Chapter 19.75 of the Salt Lake County Zoning Ordinance), site-specific geologic hazard investigations are required in special study areas, and may be required in areas within the Foothills and Canyons Overlay Zone (Chapter 19.72) and areas where site conditions indicate a potential for geologic hazards.

The Utah Geological Survey (UGS) has mapped historic landslides (Harty, 1991) and landslide susceptibility (Giraud and Shaw, 2007) for the State of Utah. The landslide susceptibility ratings were based on existing landslide areas, geologic units and slope angle of the topography. Recent landslide events in Salt Lake County investigated by UGS include East Capitol Boulevard along City Creek Canyon, which began to move in 1998.

3.8 GROUNDWATER

In Salt Lake County, a relatively deep, unconfined groundwater aquifer exists near the mountain/valley interfaces. As a result of fine grained depositional features, this unconfined aquifer becomes confined as it moves toward the center of the County and toward the Great Salt Lake. Collectively, the deeper aquifers in the Salt Lake Valley are known as the principal aquifer. Where the principal aquifer is confined, it is overlain by a shallow unconfined aquifer. The primary recharge area for the principal aquifer includes the mountains surrounding the valley and the part of the valley near the mountain/valley interface (Figure 3.8.1). Additionally, a secondary recharge area exists where water moves from the shallow aquifer to the deeper confined aquifer. This movement is possible due to a downward gradient in the bedrock layers. The confining rock layers separating the confined aquifer from the shallow aquifer are thin and/or discontinuous. In the discharge areas an upward gradient exists from the deeper confined aquifer to the overlying shallow aquifer. Of the annual precipitation that falls in the Wasatch Mountains, approximately 30–40% is transported through surface runoff, 40–60% is dissipated through evapotranspiration (evaporation through vegetation) and sublimation (direct conversion from a solid to gaseous state), and 5–20% goes into regional groundwater recharge (Manning, 2002).

Approximately 50% of the recharge to the principal aquifer is thought to come from mountain front recharge area. This includes subsurface inflow from the adjacent mountains (mountain-block recharge) and seepage from streams near the mountain front. Other major sources of recharge include: 1) infiltration of excess irrigation water from fields, lawns, and gardens, 2) infiltration of precipitation (snow and rain), and 3) seepage from canals and stormwater systems (Waddell et al., 1987; Lambert, 1995). Ultimate transportation and seepage from the shallow aquifer to the Jordan River and other surface streams comprises a significant portion of the total discharge from the principal aquifer. However, groundwater well withdrawals are thought to comprise approximately one third (1/3) of the total estimated discharge from the system. These drinking water well withdrawals for potable purposes are anticipated to increase and may ultimately effect the amount of groundwater that is discharged to both the Jordan River and its tributaries (Thiros, 1995; Waddell et al., 1987).

3.8.1 Groundwater Quality

The Utah DWQ classifies the groundwater quality and protection levels of aquifers based on total dissolved solids (TDS) and contaminant concentration. The groundwater is classified into one of four classes; from Class I pristine groundwater to Class IV saline groundwater. The aquifer in Salt Lake County, however, has not been classified by DWQ. Each year a summary report of groundwater conditions in Utah, including the Salt Lake Valley, is produced cooperatively by DWRe, DWRi, DWQ and USGS (Burden and others, 2007). The report presents observations of the concentration of chloride and TDS in groundwater.

The principal aquifer in the Salt Lake Valley has been divided into two (2) categories, confined and unconfined, according to the susceptibility of the

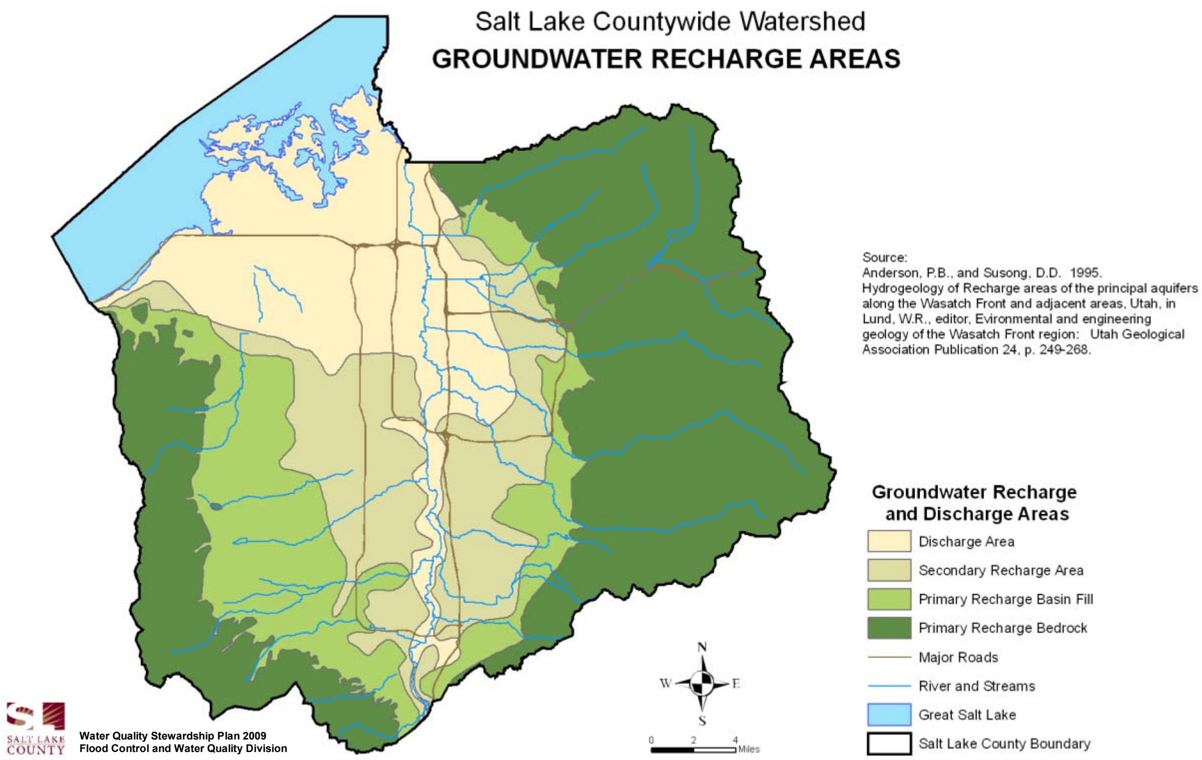


Figure 3.8.1 Groundwater Recharge Areas

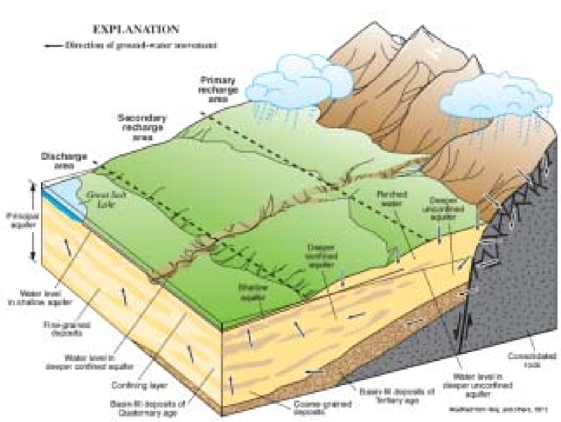
groundwater to contamination, the rate of movement or transport, and the direction of vertical hydraulic gradients (Waddell et al., 1987).

Groundwater quality depends largely on the type of rocks and associated minerals that the water has come in contact with through percolation and transmission. Additionally, the quality of groundwater is significantly impacted by the length of time over which the water is in contact with aquifer material. Analysis of well samples, collected by the USGS, suggest that groundwater in the northwestern section of Salt Lake Valley tends to be higher in sodium and chloride than groundwater in other parts of the alley. This is likely due to mineral deposits associated with the Great Salt Lake. Groundwater in the southeastern part of the valley is higher in calcium-bicarbonate type ions and thereby more prone to be hard water. Waters from the northeastern part of the valley's aquifer contains sulfates. This high sulfate content likely comes from contact with Triassic-age shale and mudstone in the mountain block and in the basin-fill deposits in and near the area (Thiros, 1995).

Groundwater in the principal aquifer generally has lower total dissolved solids (TDS) concentrations than the shallow unconfined aquifer (Hely et. al., 1971). TDS concentration ranged from 157 to 1,280 mg/L in water sampled from 31 public supply wells (Thiros and Manning, 2001) and from 331 mg/L in the eastern part of the valley to 20,900 mg/L in the northwestern part in water sampled from 30 shallow groundwater wells (Thiros, 2003). The unconfined shallow aquifer exhibits more localized variation and higher concentration of TDS due to the proximity to the land surface, evapotranspiration, dissolution of minerals and recharge water from the Jordan River (Hely et. al., 1971).

Drinking water diversion off of Willow Creek, Lower Willow Creek Sub-Watershed

Significantly, water quality in the confined part of the principal aquifer can be degraded by secondary recharge of contaminated water from the shallow aquifer. The unconfined part of the principal aquifer is vulnerable because of a lack of confining layers that can impede the downward movement of contaminated groundwater. Subsequent to the settlement of the Salt Lake Valley, three (3) areas (west of the mouth of Big Cottonwood Canyon, the secondary recharge area near Sandy, and the discharge area near Murray) have undergone an increase in TDS concentration. It is suspected that groundwater withdrawals from public and private wells may have caused changes to the vertical and/or lateral gradients of the groundwater, which would have allowed waters with high TDS concentration to infiltrate the wells in these areas.



Schematic of Basin Fill Aquifer

Although nutrients (nitrogen and phosphorus) can occur naturally in groundwater, elevated concentrations in groundwater generally are caused by human activities. Nitrate concentration in water sampled from 26 of 30 shallow groundwater wells located in recently developed (post-1963) residential and commercial areas was higher than a background level of 2 mg/L, indicating a possible human influence (Thiros, 2003). The median nitrate concentration for water from public supply wells on the east side of the valley was 1.21 mg/L compared to 3.12 mg/L on the west side (Thiros and Manning, 2001).

A Utah Geological Society study found that the bench areas of Salt Lake County have a “high sensitivity” to pesticides, while areas near the Great Salt Lake were rated with a “low sensitivity” and the majority of the valley was given a “moderate sensitivity” rating (Lowe et al., 2005). Fifteen pesticides and pesticide degradation products, of the 104 analyzed for, were detected in shallow groundwater wells in residential and commercial areas; however, no pesticides were detected at levels that exceed EPA drinking water standards (Thiros, 2003).

Generally, urban activities that may impact the quality of groundwater in Salt Lake County include, but are not limited to: 1) fertilizer and pesticide applications; 2) water extractions; 3) industrial activities such as automotive repair shops; 4) dry cleaners; 5) landfills; 5) chemical storage; and 6) oil pipelines. In order to protect drinking water supplied from groundwater sources, the majority of cities in Salt Lake County have adopted a water source protection ordinance which outlines recharge areas and land uses allowed in these recharge zones.

There are five (5) active EPA National Priority List (NPL) sites within Salt Lake County that require remediation efforts to prevent groundwater contamination: 1) Flagstaff/Davenport Smelters; 2) Kennecott North Zone Tailings Pond; 3) Kennecott South Zone Bingham Mine; 4) Midvale Slag and 5) Murray Smelter.

3.9 CLIMATE

Salt Lake County has a semi-arid continental climate with four distinct seasons (NWS, 2007). The climate in the County is generally determined by: 1) latitude, 2) elevation, 3) regional storm paths, 4) the distance from moisture sources such as the Pacific Ocean and the Gulf of Mexico, 5) local mountain ranges, and 6) the Great Salt Lake. Additionally, winds traveling inland from the Pacific Ocean must cross the Sierra Nevada or Cascade mountain ranges before reaching Salt Lake County. As moist air travels over high mountain ranges, it is forced to rise to higher altitudes causing condensation and precipitation. Therefore, westerly air currents that reach Utah are relatively dry.

Latitude and elevation impact the local climate through their influence on air pressure and solar energy. Additionally, mountains to the north and east act as barriers to frequent inflow of cold continental air from the north. The Great Salt Lake moderates winter temperatures in the County when cold winter winds blow over the relatively warm Great Salt Lake waters from the northwest. This effect can also

Kennecott Copper Mine Pit, Bingham Creek Sub-Watershed

Salt Lake Valley View from Ensign Peak

cause unstable air that contributes to what is known as “lake effect” snowstorms. Conversely, warmer lake water contributes to increased precipitation in the valley during fall, winter, and spring months.

In addition to the Great Salt Lake, the mountain ranges to east, west, and southeast of the County may effect local climate regimes. Canyon breezes are common and in extreme cases may exceed hurricane force winds. Mountain ranges also help shelter the valley from winter storms originating in the southwest, and are instrumental in developing thunderstorms, which can drift over the valley in the summer.

In Salt Lake County, summer months are typically hot and dry with low relative humidity (mean humidity is typically less than 60%) (Table 3.9.1). Winter months are cold, but usually not severe, due again to the low relative humidity. The average maximum daytime temperatures in Salt Lake City range from 37º in January to 93º in July; however, mountain temperatures can be substantially different due to altitudinal effects or temperature inversions typical in winter months. Average temperatures at the Salt Lake City International Airport range between 51.9º and 54.9º F between 1995 and 2005 (Table 3.9.1). Mean daily fluctuations in temperature can vary between 18º F in the winter months and 30º F in the summer months.

The average annual precipitation at the Salt Lake City International Airport has varied between 14 and 23 inches per year between 1995 and 2005 (Table 3.9.2). On average, the Salt Lake Valley receives less than 20 inches of rainfall per year (Figure 3.9.1). Precipitation tends to be light and isolated in the summer and fall months and heavy in the spring when frontal storms move inland from the Pacific Ocean.

Higher precipitation levels are apparent in the Wasatch and Traverse Mountains where mean annual precipitation levels reach up to 60 inches per year. Interestingly, Upper Emigration, Upper Parley’s, and Upper Mill Creek Sub-Watersheds receive lower levels of precipitation than the southern upper watersheds of Big Cottonwood, Little Cottonwood, and Corner Canyon. The highest average monthly precipitation levels are typically in April with a mean of 2.2 inches per month. The driest month of the year is July with an average precipitation of 0.7 inches (as measured) at the airport.

Table 3.9.1 Salt Lake County Climate

Year	Mean Annual Temp. (º F)	Mean Annual Relative Humidity (%)
1995	53.8	57
1996	54.2	55
1997	53.3	58
1998	52.8	61
1999	53.3	53
2000	53.7	56
2001	53.7	53
2002	51.9	53
2003	54.9	54
2004	52.0	56
2005	53.3	55

Source: National Weather Service (NWS), 2007

Table 3.9.2 Salt Lake County Precipitation

Water Year (Oct-Sept)	Mean Annual Precipitation (Inches)	Annual Snowfall (Inches)
1995 – 1996	15.0	85.7
1996 – 1997	18.5	63.3
1997 – 1998	23.4	65.2
1998 – 1999	14.7	32.2
1999 – 2000	14.4	50.3
2000 – 2001	13.9	64.7
2001 – 2002	14.1	73.5
2002 – 2003	11.8	22.3
2003 – 2004	15.7	77.5
2004 – 2005	19.2	27.9

Source: National Weather Service (NWS), 2007

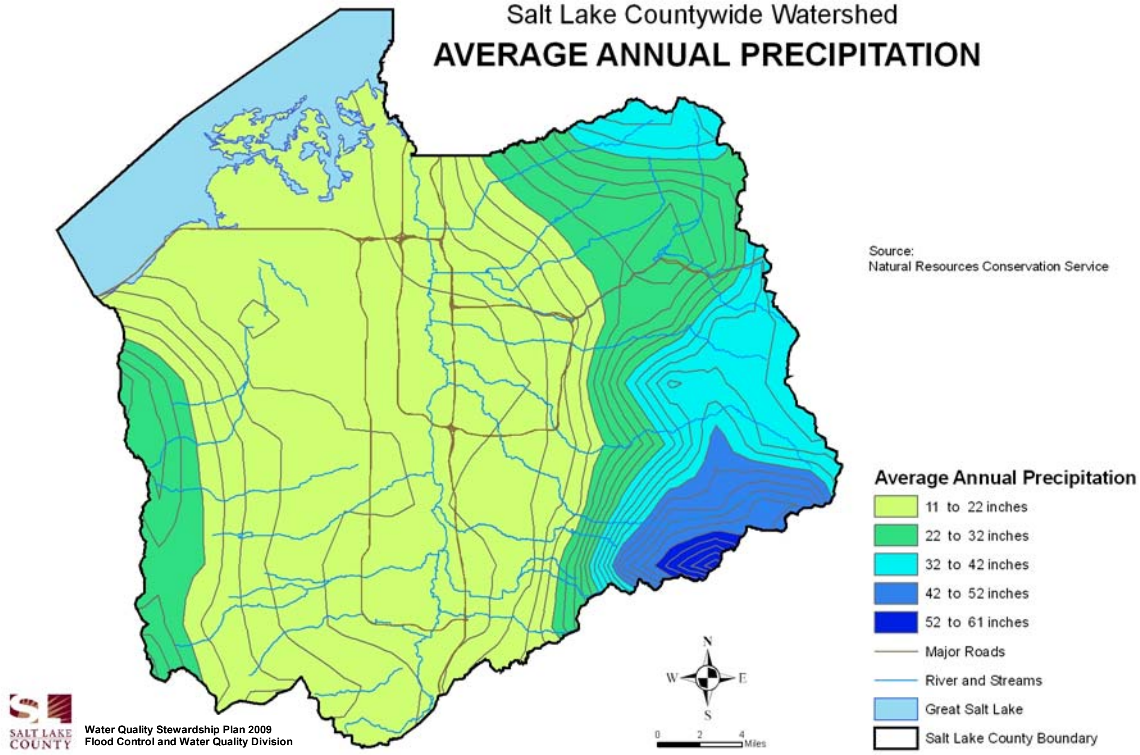


Figure 3.9.1 Average Annual Precipitation

Annual snowfall varied from 22 to 86 inches in the valley between 1995 and 2005. The higher elevation bench areas receive significantly more snowfall. Snow accumulation in the mountain areas can reach depths of 10 feet or more. At some locations, the average annual snowfall is 40 to 50 feet. Due to the state's inland location, Utah's snow is unusually dry, with less than 10% moisture content (NWS, 2007).

3.9.1 Climate Change and Salt Lake County

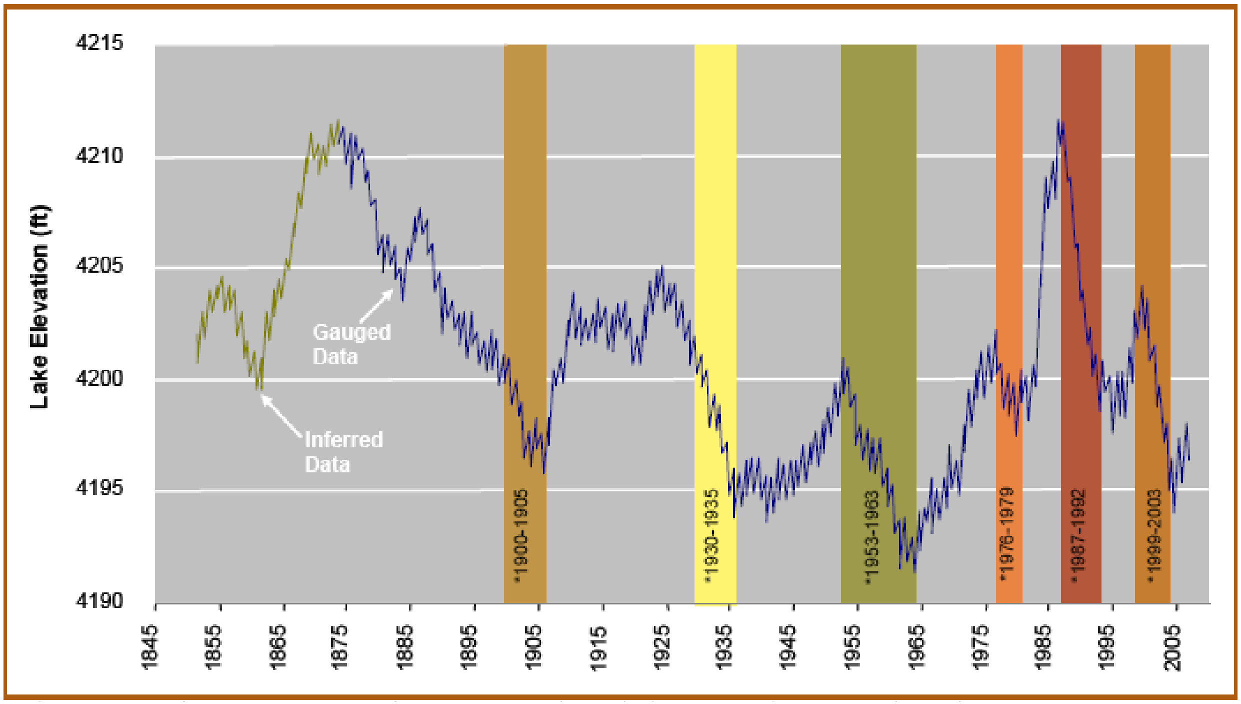
Global climate change is currently much discussed and debated. *Climate Change and Utah*, a document produced by EPA in 1998, states that the United Kingdom's Hadley Centre's climate model predicts that by 2100, summer and winter temperatures in Utah could increase by a range of two (2) to ten (10) degrees Fahrenheit. This increase would change the current amount, timing and type of precipitation. With this increase in temperature, surface water resources would be negatively affected, as well as a potential drop in groundwater levels. The Great Salt Lake may be vulnerable to a warmer climate with increasing rates of evaporation and reduced inflows leading to decreases in the size of the lake and increases in salinity (figure 3.9.2).

The Governor of Utah formed a Blue Ribbon Advisory Council on Climate Change (BRAC) in 2006. BRAC is comprised of leading scientists and academics in the state and was directed to:

1. Consider science, economics, and policy around climate change in a forum where we as a State, industry, environment, community, could have productive dialogue.
2. Understand and recognize what we are trying to leave for the next generation.
3. Bring back information and policy recommendations for review and consideration.

The following conclusions were reached in *Climate Change and Utah: The Scientific Consensus* (BRAC, 2007):

- There is no longer any scientific doubt that the Earth's average surface temperature is increasing and that changes in ocean temperature, ice and snow cover, and sea level are consistent with this global warming.



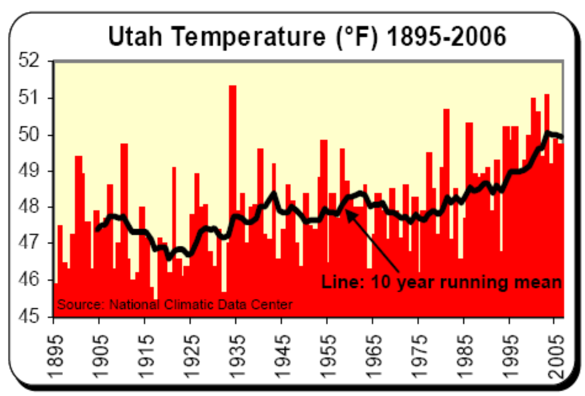
Source DWRe, 2007

Figure 3.9.2 Historic Record of Great Salt Lake Elevation

- Based on extensive scientific research, there is very high confidence that human-generated increases in greenhouse gas concentrations are responsible for most of the global warming observed during the past 50 years.
- It is likely that increases in greenhouse gas concentrations are contributing to several significant climate trends that have been observed over most of the western United States during the past 50 years. These trends are: (1) a several day increase in the frost-free growing season; (2) an earlier and warmer spring; (3) earlier flower blooms and tree leaf out for many plant species; (4) an earlier spring snowmelt and run off; and (5) a greater fraction of spring precipitation falling as rain instead of snow.
- In Utah, the average temperature during the past decade was higher than observed during any comparable period of the past century and roughly 2° F higher than the 100 year average (Figure 3.9.3).
- Utah is projected to warm more than the average for the entire globe and more than coastal regions of the contiguous United States. The expected consequences of this warming are fewer frost days, longer growing seasons, and more heat waves. As temperature increases through the century, it is likely that a greater fraction of precipitation will fall as rain instead of snow, the length of the snow accumulation season will decrease, and snowpack loss due to evaporation will increase.

Since BRAC was formed, meetings, reports and findings have been documented and can be found on the State of Utah website.

Watershed function in Salt Lake County could be impacted by an increase in average temperatures,



Source: BRAC, 2007

Figure 3.9.3 Utah historical temperature trend

including the following direct affects: reduction in snowpack and groundwater, which provide for most of the drinking water in the County; stormwater conveyance and flood control systems may need to be enlarged; wetlands and riparian habitat may be at risk; and perennial streams may become intermittent.

3.10 HYDROLOGY

Hydrology refers to the distribution and movement of groundwater and surface water within the watershed. The hydrologic cycle is the continuous movement of water through and within the atmosphere, over the landscape, and in underground systems. The hydrology of the streams in Salt Lake County is dominated by snowmelt, with higher flows occurring from April through July. Groundwater driven base flows generally occur in the streams from August through March, with rainfall causing temporary rises in flow during storms.

The hydrology of the Wasatch Mountain streams on the east side of the valley varies considerably from the upper sub-watershed areas to the lower sub-watershed areas.

The upper sub-watersheds are generally characterized by open spaces, with the primary uses being recreation and protection of water supply sources. Due to this, the flows in the upper sub-watersheds are typically more natural, originating from snowmelt, runoff and groundwater from scrub-shrub and forested areas. Once the streams enter the lower sub-watersheds, most of the tributary flows are diverted for drinking water, irrigation and industrial purposes. In addition, the land is much more intensively developed in the valley, resulting in larger stormwater flows to the streams and higher peak flows. Hydrologic modification of the streams is discussed in more detail below.

The hydrology of the Oquirrh Mountain streams on the west side of the valley is also dominated by snowmelt; however, as a result of the smaller drainage area, lower elevation and lower snowfall accumulation, these streams generally do not have flow year round. In addition, irrigation canals and storm drains intercept many of the Oquirrh Mountain streams; therefore, sources of these streams no longer flow to the Jordan River. Examples include Barney's Creek and Wood Hollow Creek .

Wasatch Mountains with snow

Significantly, all subsurface drainage from the Oquirrh Mountains to the east has been intercepted and piped to Kennecott's slurry line, tailings pond, and/or the Great Salt Lake.

The Jordan River is a highly regulated conveyance system. The hydrology is affected by managed releases from Utah Lake, diversions into irrigation canals, inflows from tributaries, discharges from three wastewater treatment plants and diversion into the Surplus Canal for flood control purposes.

Streams in the Great Salt Lake Sub-Watershed flow directly to the lake and do not enter the Jordan River. Runoff is generally collected in canals and storm drains for discharge to the lake. Only a small section of open-channel stream remains in this sub-watershed.

3.10.1 Hydrologic Modification

Hydrologic modifications encompass all human activities that "significantly change" the hydrologic function and/or pollutant loads in streams, rivers, lake, and groundwater systems (DEQ, 2000). The effects of hydrologic modifications can be divided into three (3) main categories:

1. <u>Instream Flow Alteration</u>: Activities that may alter the flow regime of water bodies include: 1) diversions of streams, 2) impoundments or dams, 3) vegetation removal or change in type of vegetation, 4) construction that leaves bare soil or covers the existing soil (hardtop), 5) activities that change capacity, circulation patterns, or release of stored pollutants from

Lakes and/or Reservoirs, 6) activities that may effect groundwater recharge patterns such as direct recharge and pumping from groundwater systems.

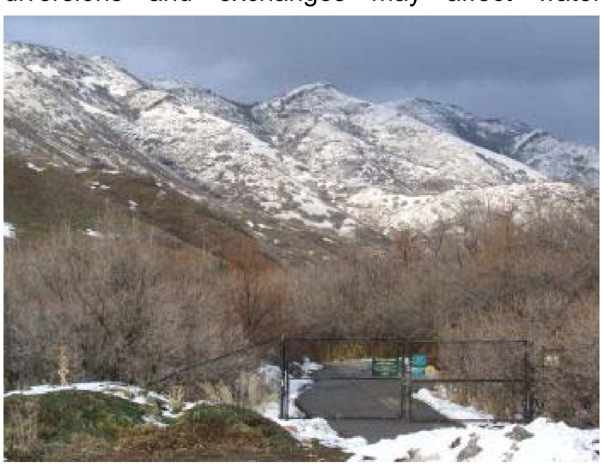
2. Stream Channel Alteration: Activities that may alter the shape and size of stream channels include: 1) channel diversions, 2) channel realignment, 3) channel straightening, 4) floodplain channel realignment, 5) grade control structures, 6) in-stream structures, 7) stream crossings, 8) bank stabilization activities, and 9) mineral extractions.

3. Flood Control: Activities that may effect floodplain areas include: 1) riparian/floodplain modification, 2) stabilization structures, and 3) wetland loss and/or modification.

3.10.1.1 Hydrologic Modification – Instream Flow

Instream flow is defined as water in the stream channel that is generated by surface runoff (snow melt, overland flow, storm flow, and return irrigation flow), shallow subsurface flow, and/or groundwater from the watershed. Instream flows maintain the existing aquatic resources and associated wildlife and riparian habitat. In urban areas, riparian habitat may be supported through irrigation practices. The United States Geological Survey (USGS) designates stream channels as either intermittent or perennial. Intermittent streams flow for a portion of the year or seasonally. Perennial streams have in-stream flow continuously throughout the year.

Hydrologic modification of instream flows through diversions and exchanges may affect water quality, stream channel stability, as well as aquatic and riparian habitat. For this study, the streams in Salt Lake County were categorized to indicate the impact of flow modification (Table 3.10.1). Three (3) flow modification categories were defined: reduced, reduced with exchange, and interrupted. The following definitions for the established flow modification categories are:



Upper City Creek Sub-Watershed

- Reduced: Stream reaches where instream flows are decreased due to diversions for water supply, irrigation, and/or power generation. Only diversions to canals or community irrigation systems were used to identify streams with reduced flows in Salt Lake County. Minor diversions to individual properties were not considered.
- Reduced with Exchange: Stream reaches where instream flows have been removed and replaced with water from another source (e.g., such as irrigation waters) through water rights exchange agreements. This category only applies to sections of Little Cottonwood Creek, Big Cottonwood Creek, and Mill Creek.
- Interrupted: Stream reaches which are completely dewatered for any duration during the year as a result of diversions for water supply, irrigation and/or power generation.

For the purposes of this plan, USGS stream designations were combined with the hydrologic modification definitions, result in seven (7) instream flow categories:

1. Intermittent (Int)
2. Intermittent Reduced (Int/Rd)
3. Intermittent Interrupted (Int/Irpt)
4. Perennial (P)
5. Perennial Reduced (P/Rd)
6. Perennial Reduced with Exchange (P/Rd w exchange)
7. Perennial Interrupted (P/Irpt)

Each reach of the main stem tributaries was assigned to an instream flow category by Salt Lake County staff based on institutional knowledge of the stream systems, review of previous studies (Coon King and Knowlton Engineers et al., 1982; DWR, 1997), flow gage data, and water rights records. This information was used to determine the length

Table 3.10.1 Flow Categorization of Salt Lake County Streams

Stream	Watershed	Intermittent Stream Miles				Perennial Stream Miles					Grand Total
		Natural	Interrupted	Reduced	Total	Natural	Interrupted	Reduced	Reduced/ Exchange	Total	
Barney's Creek	Barney's Creek	6.1			**6.1**	2.3				**2.3**	**8.4**
Beef Hollow	Jordan River	5.5			**5.5**						**5.5**
Big Cottonwood Creek	Big Cottonwood Creek					11.1	4.2	2.5	6.3	**24.1**	**24.1**
Big Willow Creek	Willow Creek		3.0		**3.0**	1.2				**1.2**	**4.1**
Bingham Creek	Bingham Creek		7.9		**7.9**		2.3			**2.3**	**10.2**
Burr Fork	Emigration Creek	2.6			**2.6**						**2.6**
Butterfield Creek	Midas/Butterfield Creek	1.7		3.0	**4.7**	3.5				**3.5**	**8.1**
City Creek	City Creek					6.7		3.6		**10.3**	**10.3**
Coon Creek	Coon Creek	5.3			**5.3**	2.5				**2.5**	**7.8**
Copper Creek	Midas/Butterfield Creek	5.3			**5.3**						**5.3**
Corner Canyon Creek	Corner Canyon Creek	2.4	5.5		**7.9**						**7.9**
Dry Creek	Dry Creek		8.8		**8.8**		0.5			**0.5**	**9.3**
Dry Creek (Bell's Canyon)	Dry Creek					2.2				**2.2**	**2.2**
Emigration Creek	Emigration Creek	2.9			**2.9**	5.0		5.5		**10.5**	**13.4**
Harker's Canyon	Coon Creek	7.8			**7.8**						**7.8**
Jordan River	Jordan River							43.8		**43.8**	**43.8**
Kersey Creek	Great Salt Lake					2.6					**2.6**
Lambs Canyon	Lambs Canyon					5.1				**5.1**	**5.1**
Lee Creek	Great Salt Lake	2.2			**2.2**	1.8				**1.8**	**4.0**
Little Cottonwood Creek	Little Cottonwood Creek					9.3	7.7		5.3	**22.3**	**22.3**
Little Willow Creek	Willow Creek		1.9		**1.9**	3.0				**3.0**	**4.8**
Midas Creek	Midas/Butterfield Creek	10.1			**10.1**						**10.1**
Mill Creek	Mill Creek					11.0		7.5		**18.5**	**18.5**
Mountain Dell Canyon	Parley's Creek					5.4		0.8		**6.2**	**6.2**
Parley's Creek	Parley's Creek			2.4	**2.4**	3.4		10.5		**13.9**	**16.3**
Red Butte Creek	Red Butte Creek			2.5	**2.5**	2.9		2.5		**5.4**	**7.9**
Rose Creek	Rose Creek		8.9		**8.9**	2.3				**2.3**	**11.2**
Willow Creek	Willow Creek		6.8		**6.8**						**6.8**
Wood Hollow	Jordan River	5.0			**5.0**						**5.0**
Total		**56.8**	**42.7**	**7.8**	**107.3**	**81.3**	**14.7**	**81.8**	**11.6**	**189.5**	**296.7**

of the stream in each sub-watershed categorized as reduced or interrupted.

Figure 3.10.1 shows the instream flow type of each stream segment. Figure 3.10.2 presents the percentage of stream length that is either reduced or interrupted in each sub-watershed. Eight (8) of the sub-watersheds have no flow reductions, four (4) of these being on the east side and four (4) on the west side. Generally, the largest percentage of stream segments with reduced/interrupted flows is in the valley sub-watersheds, particularly on the east side. The reductions/interruptions are primarily due to diversions for water supply purposes, either for drinking water or irrigation uses. The mountain sub-watersheds generally have lower percentages of reduction/interruption.

This analysis does not assess the level of flow modification, only whether reduction/interruption is occurring. In addition, the Jordan River is a highly managed system with complex flow conditions that requires separate consideration. Further analysis and discussion of flow modification is presented under Instream Flows Planning Element (Section 4.6).

Most of the urban sub-watersheds have streams with reduced or interrupted flow conditions (Figure 3.10.1 and 3.10.2). This can be generally attributed to irrigation and water rights diversions.

Stream flows can also be augmented with return flow from irrigation and discharges from wastewater treatment plants. Excess water applied to agricultural crops or lawns is returned to the stream channel via surface outlets or groundwater.

Jordan River in Riverton City, Jordan River Corridor Sub-Watershed

Irrigation return flow can be a large contributor to instream flows in rural areas, as well as wastewater treatment plants discharging treateded effluent. Two (2) wastewater treatment plants (refer to Section 4.2) currently discharge to the Jordan River within Salt Lake County.

3.10.1.2 Hydrologic Modification – Stream Channel

Refer to Section 3.11.2 below under Geomorphology for a discussion of modifications made to stream channels.

3.10.1.3 Hydrologic Modification - Flood Control

Flood control facilities in Salt Lake County are designed to convey runoff from rain and snow storms and snowpack melt in the spring. The difference in design for these structures is attributed to different flow situations. Runoff from a rain storm is usually of short duration (matter of hours) and can be quite dramatic with flowrates rising an order of magnitude or more, then subsiding as the storm wanes. Snowmelt runoff differs in that when the snowpack begins to melt, flowrates in the tributaries rise with the heat of the day but lag behind about one-third to one-half day due to travel time. Daily peak flowrates in the tributaries usually occur late in the evening to midnight. When snowmelt is occurring, daily peak flowrates gain in magnitude day after day as do the daily low flowrate until the snowmelt peak flow, after which flowrates begin to drop.

Flood control facilities in Salt Lake County consist of a system of local municipal drainage pipe and open channel drainage facilities which discharge to a larger Countywide system of pipe, open channel, canal or natural stream and river channel conveyances, all eventually discharging to the Great Salt Lake.

The local drainage systems are planned, constructed, operated and maintained in incorporated areas by municipal governments and by the County in unincorporated areas. These systems are usually designed to convey runoff from a 10-year storm (a precipitation value from a storm that statistically should occur once in 10 years time). The larger receiving system is operated by the County under provisions of Chapter 17 of the Salt Lake County Code of Ordinances. The Countywide

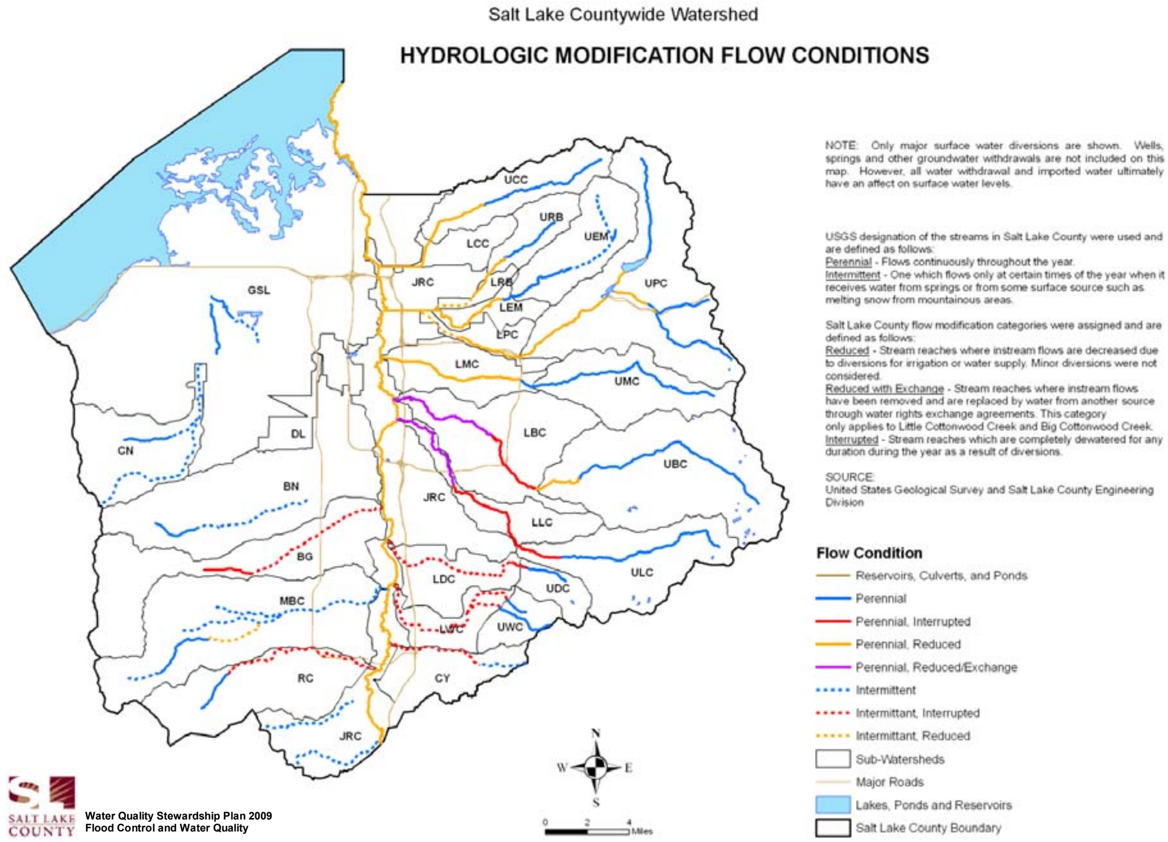


Figure 3.10.1 Hydrologic Modification Flow Conditions

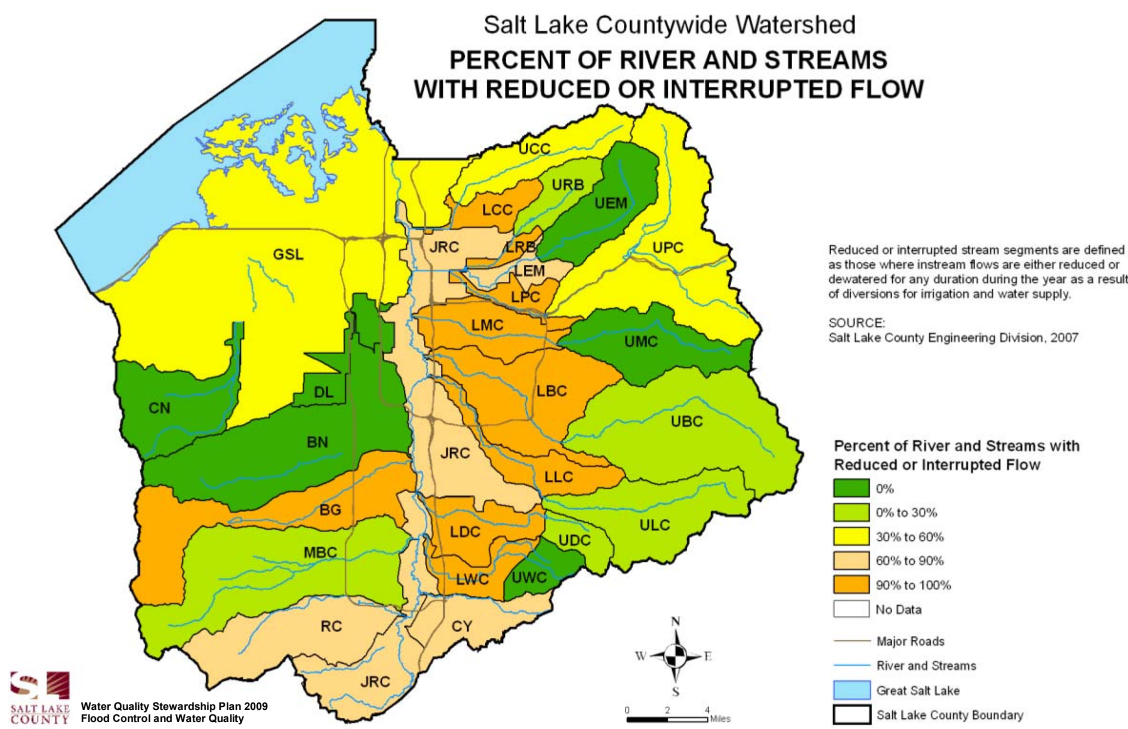


Figure 3.10.2 Rivers and Streams with Reduced or Interrupted Flow

system of major facilities, is usually designed to convey the runoff from a 100-year storm. The facilities in the Countywide system usually convey flows that cross jurisdictional (City) boundaries and are shown in Figure 3.10.3.

Included in the drainage systems (both municipal and Countywide) are detention and debris basins. Detention basins are designed to detain peak flows generated from a storm and release the stored water after the peak flows have occurred. This allows for a more controlled flow situation and for a savings in construction costs due to smaller pipe size requirements. Detention basins are not practical for managing snowmelt runoff due to the magnitude of runoff volume produced by the melt. Debris basins are located on some of the Wasatch Mountain creeks, usually near the canyon mouth. The function of a debris basin is to trap debris (rock, sediment, other trash and objects) that is being carried down the channel by high flows. Without these basins, debris accumulates in channels when flow velocities slow, reducing necessary channel capacity which results in water overtopping the channel and causing flooding. Debris basins are practical for both storm and snowmelt runoff because they do not detain water, just the debris carried by the water. These facilities are shown in Figure 3.10.4.

County governments were granted countywide flood control authority by the State in the 1920's. Flood control functions in Salt Lake County were managed by various agencies until 1965 when the County adopted Chapter 17 of the Salt Lake County Code of Ordinances. This ordinance centralized flood control management under County Flood Control and set in place a Flood Control Permit program to manage a defined countywide system of major facilities.

The permit program requires permits for connections from local (municipal) drainage facilities. The Flood Control Permit has flow rate conditions as well as physical connection conditions placed upon the application. This permit also may include environmental requirements. The Flood Control Permit is coordinated with the Corps of Engineer's 404 Permit program and the State's Stream Alteration Permit program. Environmental conditions regarding the physical channel and adjacent areas may also be included in the federal and state permits.

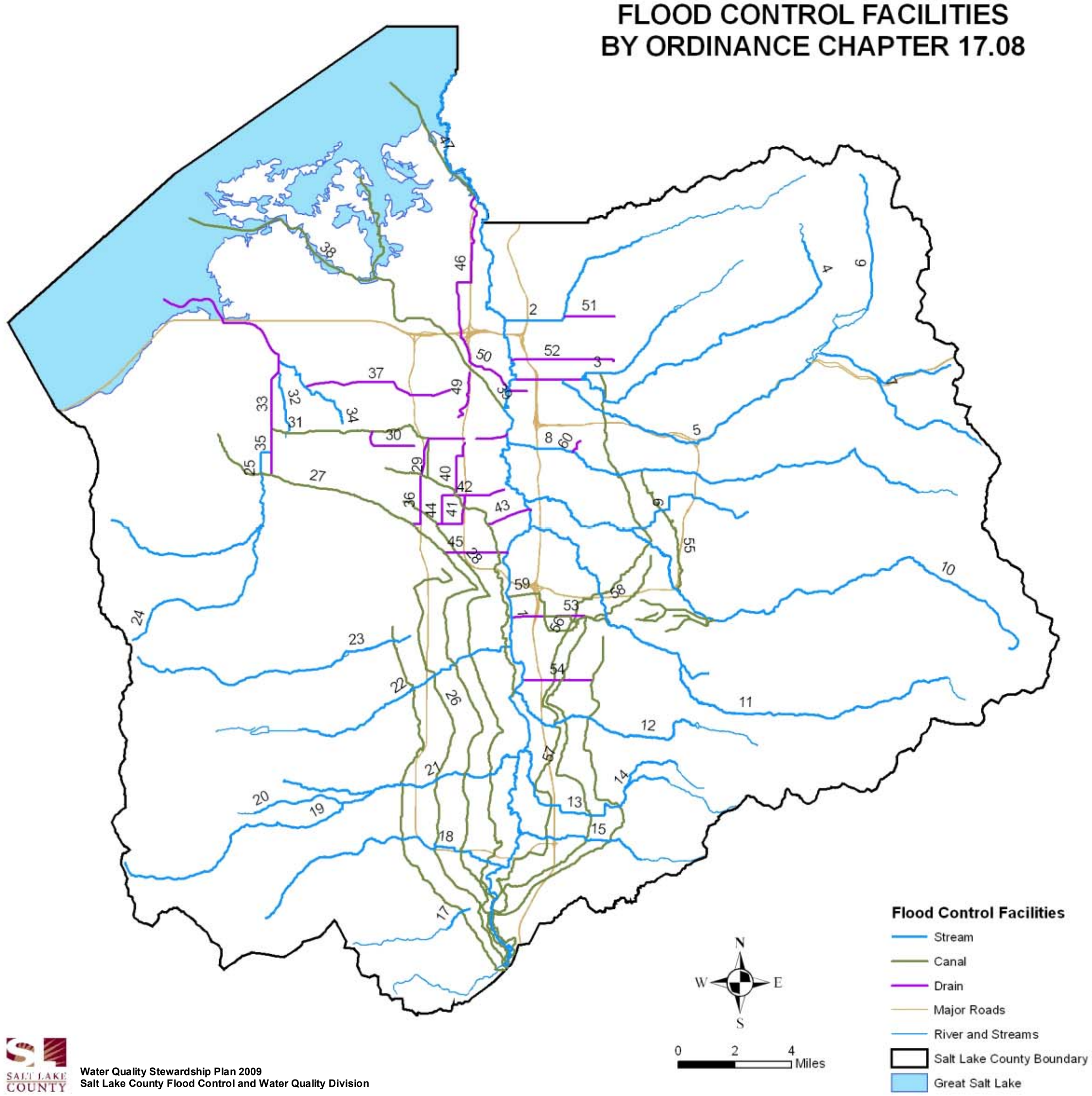
Big Cottonwood Creek below Creek Road, Lower Big Creek Sub-Watershed

An integral part of the Countywide drainage system is the irrigation canal system. The topography of the County results in the majority of runoff draining to the Jordan River which flows south to north, bisecting the County, to the Great Salt Lake.

Traversing the valley parallel to the Jordan River is a series of irrigation canals which were originally constructed for crop and field irrigation. As the County transitioned from rural to urban, storm drainage was directed to this canal system. Where the canal crosses a natural waterway, an overflow structure was constructed to reduce the flow in the canal. Where a natural waterway does not exist, an overflow to a piped system was constructed. An outcome of this arrangement is that diverted irrigation water from the Jordan River is discharged into the tributaries during storm runoff events in addition to accumulated stormwater runoff.

3.11 GEOMORPHOLOGY

Geomorphology refers to the formation and evolution of streams and rivers through the interaction between water and the landscape. Rivers and streams convey water and sediment downstream, generally increasing in size and merging with other streams in a dendritic pattern (formed similar to a tree with branches of different sizes). The rate of sediment transport within a watershed has a large impact on the morphology of a stream network.



NAME	ORDINANCE NO.	MILES
Jordan River	1	43.6
City Creek	2	6.9
Red Butte Creek	3	8
Emigration Creek	4	16.4
Parleys Canyon Creek	5	18.4
Mountain Dell Canyon Creek	6	5.9
Lambs Canyon Creek	7	5.1
Mill Creek	8	17
Neffs Creek	9	5.5
Big Cottonwood Creek	10	24.4
Little Cottonwood Creek	11	20.9
Dry Creek	12	9.2
Big Willow Creek	13	9.5
Little Willow Creek	14	1.9
Corner Canyon Creek	15	5.2
Beef Hollow Creek	16	0.2
Wood Hollow Creek	17	1.2
Rose Creek	18	11.2
Butterfield Creek	19	9.9
Copper Creek	20	4.7
Midas Creek	21	10.3
Bingham Creek	22	9.1
Barneys Creek	23	10.5
Harkers Canyon Creek	24	7.9
Coon Canyon Creek	25	9.9
Utah Lake Distributing Canal	26	11.9
Utah and Salt Lake Canal	27	24.7
South Jordan Canal	28	18.1
North Jordan Canal	29	11.2
Kennecott Canal	30	2
Riter Canal	31	6.6
Kersey Creek	32	2.3
C-7 Ditch	33	8
Lee Creek	34	3.9
8000 W Drain	35	1.7
Kearns-Chesterfield Drain	36	5.8
Lee Drain	37	5.4
Goggin Drain	38	7.8
Surplus Canal	39	11.8
2700 West Drain	40	1.8
I-215 Drain	41	1.5
4100 South Drain	42	2.2
4700 South Drain	43	2.5
3200 West Drain	44	1
5400 South Drain	45	2.2
City Drain West Branch	46	6.1
Sewage Canal	47	5.1
CWA-2 Drain	48	0.6
CWA-3 Drain	49	1.9
CWA-1 Drain	50	2.4
4th Avenue Drain	51	1.8
8th South Drain	52	3.7
7200 South Drain	53	2.7
9000 South Drain	54	2.5
Upper Canal	55	5.5
Jordan and Salt Lake City Canal	56	25.4
East Jordan Canal	57	17.7
East Jordan Canal Extension	58	3.7
Union Jordan No and South Ditches	59	6.6
2700 South Storm Drain	60	0.6

Figure 3.10.3 Flood Control Facilities by Ordinance Chapter 17.08

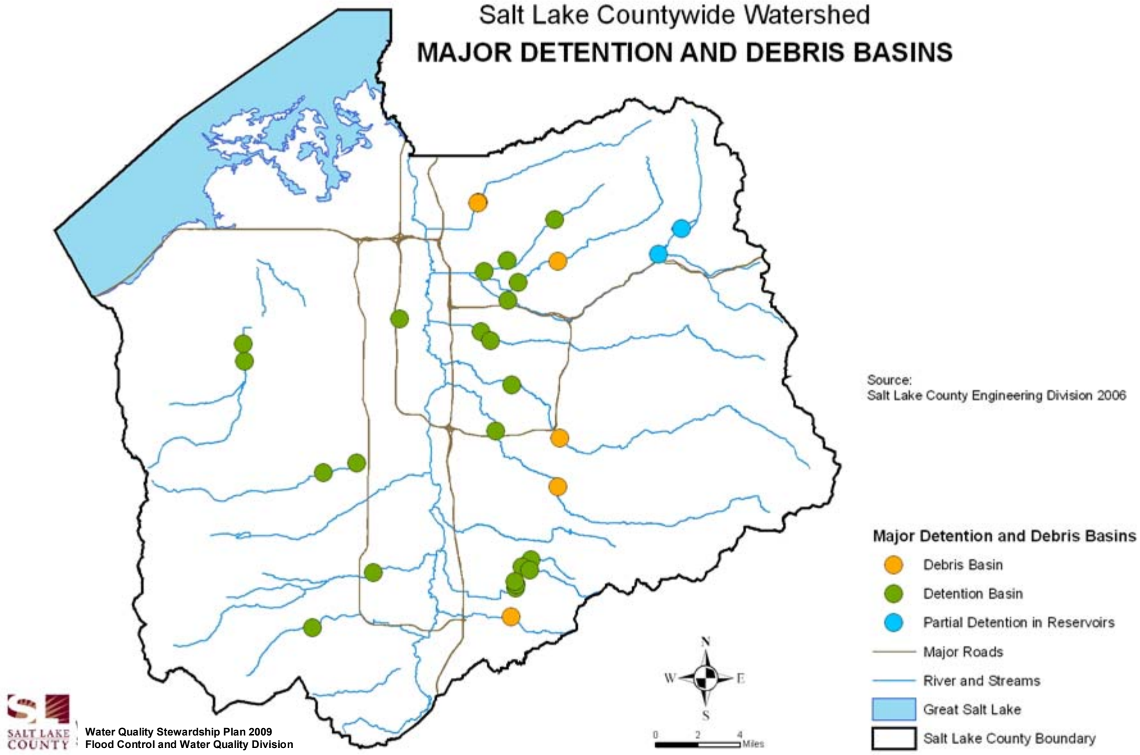


Figure 3.10.4 Major Detention and Debris Basins

Streams in the Wasatch Mountain and Oquirrh Mountain upper sub-watersheds are generally steeper with a narrower floodplain and a greater ability to transport sediment than streams in the valley. Stream slope typically flattens in the valley, resulting in increased sediment deposition and wider floodplains. Historically, the streams in the valley were straightened, channelized and disconnected from the floodplain as a result of agricultural practices and urbanization. Dredging has often been required to maintain the channels through these flat sections for flood control purposes. Additionally, many sections of streambank have been hardened with concrete retaining walls, rip rap and rock gabions in order to reduce erosion during flood flows. Finally, portions of some of the streams have been piped, resulting in the elimination of the channel entirely.

Midas Creek Detention Basin, Midas/Butterfield Creek Sub-Watershed

3.11.1 Geomorphology—Stream Stability

A naturally stable stream channel maintains its dimension, pattern and profile such that the stream does not degrade (erosion) or aggrade (deposition). Stream stability is not the absence of erosion and deposition; rather sediment transport should occur such that the channel is self-maintaining and in a state of dynamic equilibrium. Instability arises when scouring causes the channel bed to erode, excessive deposition causes the channel bed to rise, or excessive erosion causes the stream banks to fail. Channel stability is influenced by hydrologic, ecological and anthropogenic factors. Typical causes of excessive erosion and deposition include: 1) substantial changes to the hydrologic characteristics of the watershed as a result of land use changes or flow modification, and 2) physical changes to the stream form as a result of dredging, channelization or vegetation removal.

Salt Lake County staff conducted stream channel stability assessments using procedures described in the USDA Forest Service manual "Stream Reach Inventory and Channel Stability Evaluation" (Pfankuch, 1975). The assessment protocol involves field evaluation and rating of 15 stream stability indicators. The 15 indicators are aggregated into an overall rating of poor, fair, good or excellent stability for each stream reach. Of note, modifications were made to the Pfankuch methodology in order to accommodate the urban characteristics of Salt Lake County, including engineered structures. Field bank stability assessments were conducted between 2003 and 2007 on most main tributary stream segments except for the Jordan River, Upper Dry Creek and Upper Willow Creek. Only open channel stream segments were assessed; closed segments such as culverts or pipes were not evaluated. Piped sections accounted for significant portions of some sub-watersheds, including Lower City Creek, Lower Red Butte Creek, Lower Emigration Creek, and Lower Parley's Creek (Table 3.11.1). Overall Pfankuch ratings for each sub-watershed are summarized in Table 3.11.2. Notably, portions of some sub-watersheds were not assessed, including the Jordan River.

In addition to the overall Pfankuch score, Figure 3.11.1 shows the percentage of assessed stream length with a stream stability rating of poor or fair for either the upper bank, lower bank, or stream bed.Lower Red Butte Creek (95.0%), Lower Parley's Creek (94.3%) and Lower Mill Creek (91.6%) had the highest percentage of poor or fair ratings, followed by Lower Emigration Creek (91.1%), Lower Dry Creek (82.5%) and Lower Red Butte Creek (81.5%).

Table 3.11.1 Natural Channel and Culverted Stream Lengths for Assessed Streams

Sub-Watershed	Culvert		Open Channel		Reservoir		Total
	Length (feet)	Percent	Length (feet)	Percent	Length (feet)	Percent	Length (feet)
Barney's Creek	4,395	10%	39,829	90%	0	0%	44,224
Upper Big Cottonwood Creek	256	0%	72,384	100%	0	0%	72,639
Lower Big Cottonwood Creek	2,572	5%	52,209	94%	675	1%	55,457
Bingham Creek	8,020	15%	45,114	84%	622	1%	53,755
Upper City Creek	849	2%	53,675	98%	0	0%	54,524
Lower City Creek	12,016	64%	6,421	34%	291	2%	18,728
Coon Creek	8,760	11%	73,524	89%	0	0%	82,285
Corner Canyon Creek	3,162	8%	37,650	90%	958	2%	41,770
Upper Dry Creek	0	0%	12,615	100%	0	0%	12,615
Lower Dry Creek	3,141	7%	44,718	93%	0	0%	47,859
Upper Emigration Creek	2,396	5%	49,358	95%	257	0%	52,011
Lower Emigration Creek	11,094	40%	16,457	60%	0	0%	27,551
Great Salt Lake of SLCo	1,936	6%	32,864	94%	0	0%	34,799
Jordan River Corridor	1,318	0%	285,422	100%	0	0%	286,740
Upper Little Cottonwood Creek	1,288	2%	60,806	98%	0	0%	62,094
Lower Little Cottonwood Creek	2,784	5%	53,383	94%	577	1%	56,744
Midas/Butterfield Creek	8,615	7%	115,603	93%	487	0%	124,704
Upper Mill Creek	608	1%	54,591	99%	0	0%	55,199
Lower Mill Creek	3,589	8%	38,002	88%	1,351	3%	42,941
Upper Parley's Creek	25,173	19%	91,549	71%	12,798	10%	129,519
Lower Parley's Creek	23,156	61%	14,393	38%	516	1%	38,065
Upper Red Butte Creek	849	4%	20,988	91%	1,312	6%	23,149
Lower Red Butte Creek	5,394	29%	13,374	71%	0	0%	18,768
Rose Creek	5,014	8%	54,189	92%	13	0%	59,217
Upper Willow Creek	0	0%	21,194	100%	0	0%	21,194
Lower Willow Creek	11,141	18%	51,092	82%	0	0%	62,233

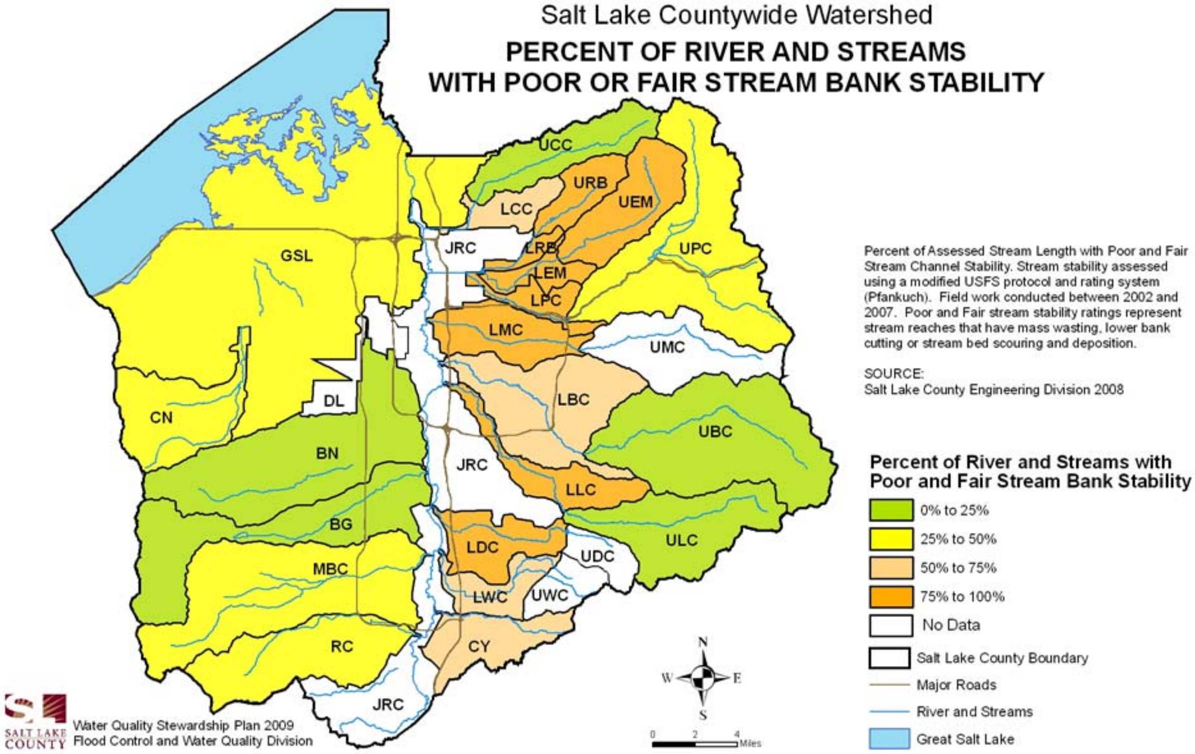


Figure 3.11.1 Stream Bank Stability

Big Willow Creek with incised channel condition, Lower Willow Creek Sub-Watershed

3.11.2 Geomorphology—Stream Channel Modifications

Physical modifications have historically been made to nearly all the stream channels in the Salt Lake Valley as a result of agricultural practices and urbanization. This section describes the types of modifications that have generally occurred in the watershed. The frequency and specific location of all types of stream channel modifications were not evaluated as part of this characterization due to the numerous occurrences and a lack of readily available historical data. However, an assessment was made of the level of hydraulic alteration of the natural stream channel through engineered stream stabilization modifications such as concrete sidewalls, rock gabions and rip-rap armoring. Each stream reach was assigned one of five categories indicating average percent of natural channel (<5%, 5-25%, 25-50%, 50-75%, and 75-100%).

Stream alignments have been straightened and channelized, removing natural sinuosity (bending, winding or curving in a stream or river). The motivation for these activities was typically to route the stream channel along property boundaries or to avoid conflicts with infrastructure such as roads and railroads. Often the streams were channelized with the intention of more effectively conveying flood flow. Channel straightening has the effect of increasing stream slope, which changes the energy dynamics of the flow and increases the potential for bank erosion and channel downcutting.

Modifications were subsequently made in order to protect the stream bank and channel bottom. Typical types of stream bank stabilization measures included concrete retaining walls or lining, rip rap armoring and rock gabion toe and wall protection. Typical measures to prevent channel downcutting included grade control structures and concrete lining. These types of engineered protection measures can be effective, but typically do not provide for natural habitat.

In lower, flatter sections at the mouth of streams, channelization resulted in increased sediment deposition due to increased upstream erosion. Historically, dredging of sediments has been required to maintain flatter reaches of stream and maintain conveyance capacity.

Other stream channel modification practices included placing the stream in a culvert at road, railroad and canal crossings. Some streams were completely enclosed in a pipe as a result of urbanization and transportation development, including Lower City Creek, Lower Red Butte Creek, Lower Emigration Creek and Lower Parley's Creek. In addition, a long section of Upper Parley's Creek is piped along Interstate 80 in Parley's Canyon. A portion of Barney's Creek was completely eliminated and the flow is now conveyed in storm drains to the Jordan River and through canals to the Great Salt Lake.

Engineered sections accounted for significant portions of some sub-watersheds, particularly Lower Willow Creek, Lower City Creek, Lower Mill Creek, Lower Emigration Creek and Rose Creek (Table 3.11.3).

Table 3.11.2 Natural and Engineered Stream Lengths

Sub-Watershed	Natural		Engineered		Total
	Length (feet)	Percent	Length (feet)	Percent	Assessed (feet)
Barney's Creek	30,038	75%	9,791	25%	39,829
Upper Big Cottonwood Creek	62,869	87%	9,515	13%	72,384
Lower Big Cottonwood Creek	47,875	82%	10,659	18%	58,534
Bingham Creek	35,250	78%	9,864	22%	45,114
Upper City Creek	33,012	83%	6,937	17%	39,948
Lower City Creek	4,040	63%	2,381	37%	6,421
Coon Creek	61,929	88%	8,847	13%	70,777
Corner Canyon Creek	31,461	84%	6,190	16%	37,650
Upper Dry Creek	Not Assessed				
Lower Dry Creek	44,452	91%	4,269	9%	48,720
Upper Emigration Creek	50,117	97%	1,732	3%	51,849
Lower Emigration Creek	15,749	71%	6,394	29%	22,143
Great Salt Lake of Salt Lake County	28,052	88%	4,007	13%	32,059
Jordan River Corridor	47,703	88%	6,815	13%	54,518
Upper Little Cottonwood Creek	53,205	88%	7,601	13%	60,806
Lower Little Cottonwood Creek	52,564	92%	4,424	8%	56,988
Midas/Butterfield Creek	97,690	85%	17,900	15%	115,590
Upper Mill Creek	47,185	86%	7,406	14%	54,591
Lower Mill Creek	26,505	70%	11,496	30%	38,002
Upper Parley's Creek	66,239	87%	9,949	13%	76,189
Lower Parley's Creek	4,256	88%	608	13%	4,864
Upper Red Butte Creek	17,971	86%	3,017	14%	20,988
Lower Red Butte Creek	12,880	87%	1,850	13%	14,730
Rose Creek	38,614	71%	15,575	29%	54,189
Upper Willow Creek	Not Assessed				
Lower Willow Creek	18,645	36%	32,446	64%	51,092

3.11.3 Geomorphology—Floodplain Development

Floodplains perform an important hydrologic function in stream and river systems. Floodplains convey and attenuate flood flows that overtop the streambank, thereby reducing downstream flooding and erosion potential. Development in the floodplain results in reduced flood capacity and increased peak flows. In many areas in Salt Lake County, the stream channels have been deepened and widened in order to convey flood flows and protect adjacent urbanization. These practices reduce the area potentially inundated by floods; however, they also disconnect streams from their historic floodplain.

Although flood flows can be accommodated through increased channel capacity, the resulting disconnect between streams and adjacent floodplains often increases flow energy and results in downstream erosion, as well as diminishes the health of the riparian vegetation community, resulting in habitat loss.

The National Flood Insurance Program (NFIP) was established in 1968 to facilitate active floodplain management by communities. Floodplain management involves taking corrective and preventative measures for reducing flood damage, including zoning, subdivision, and building requirements, as well as special purpose floodplain ordinances. The Federal Emergency Management Agency (FEMA) determines the current boundary of the 100-year floodplain for the purposes of flood insurance requirements. A 100-year floodplain is typically described as the boundary of an area subjected to a one percent probability of flooding in any given year. The FEMA 100-year floodplain boundary may or may not correspond with the historic and natural floodplain, depending on factors such as stream flow modification or regulation, and channel and overbank modification.

Rose Creek during flooding event, Rose Creek Sub-Watershed

In order to characterize the percent of the current FEMA floodplain with development, and to identify properties requiring flood insurance, an assessment was conducted to evaluate the potential for flooding impacts. The FEMA 100-year floodplain boundary was used for the analysis (FEMA, 2002), including Zones A, AE, AH and ANI (Table 3.11.4). The development adjacent to and within the floodplain was delineated using the 2006 National Agricultural Imagery Program (NAIP) 1-meter resolution color aerial photographs. Development for this planning assessment considered any structures and infrastructure within the FEMA floodplain, including buildings, parking lots and road crossings. If a lot had development within the FEMA floodplain, the entire floodplain area for that lot was considered to have development.

The percent of development in the FEMA floodplain was calculated by overlaying the delineated development area onto the 100-year floodplain. The assessment was only conducted on the main stem streams in each sub-watershed that had a designated FEMA floodplain.

The percentage of development in the FEMA floodplain for each sub-watershed is presented in Figure 3.11.2. The sub-watersheds with the highest level of development were generally on the east side of the valley, including Lower Mill Creek, Lower Big Cottonwood Creek, Lower Little Cottonwood Creek, Lower and Upper Willow Creek and Corner Canyon Creek. Lower percentages of development were observed in the west side sub-watersheds, and the lowest level of development was in the mountain segments of the east side streams.

The east side of the valley generally developed earlier and prior to the institution of regulation of development in the floodplain, which explains the high percentages of development in this area. Floodplain development in the upper sub-

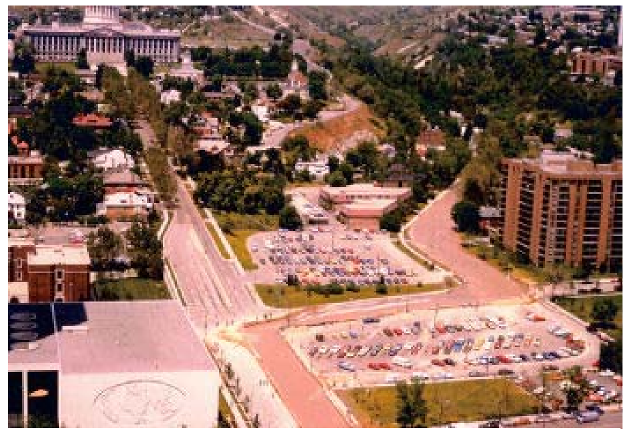
Table 3.11.3 Description of Floodplain Zones

Floodplain Zone	Description
A	Zone A is the flood insurance rate zone that corresponds to the 1-percent annual chance floodplains that are determined in the Flood Insurance Study by approximate methods of analysis.
AE	Zones AE and A1-A30 are the flood insurance rate zones that correspond to the 1-percent annual chance floodplains that are determined in the Flood Insurance Study by detailed methods of analysis.
AH	Zone AH is the flood insurance rate zone that corresponds to the areas of 1-percent annual chance shallow flooding with a constant water-surface elevation (usually areas of ponding) where average depths are between 1 and 3 feet.

Source: FEMA

watersheds in the eastern portion of the County is concentrated around the main roadways that run up each of the Wasatch Canyons.

Current floodplain best management practices dictate that a floodplain ordinance be approved that specifies what development may occur and what measures need to be taken for development to occur in the floodplain. The west side of the valley developed more recently and is continuing to experience rapid growth. The regulation of floodplain development, as well as the lack of development in the far western areas, has resulted in less encroachment in the floodplain.



1983 Flood through Salt Lake City, Lower City Creek Sub-Watershed

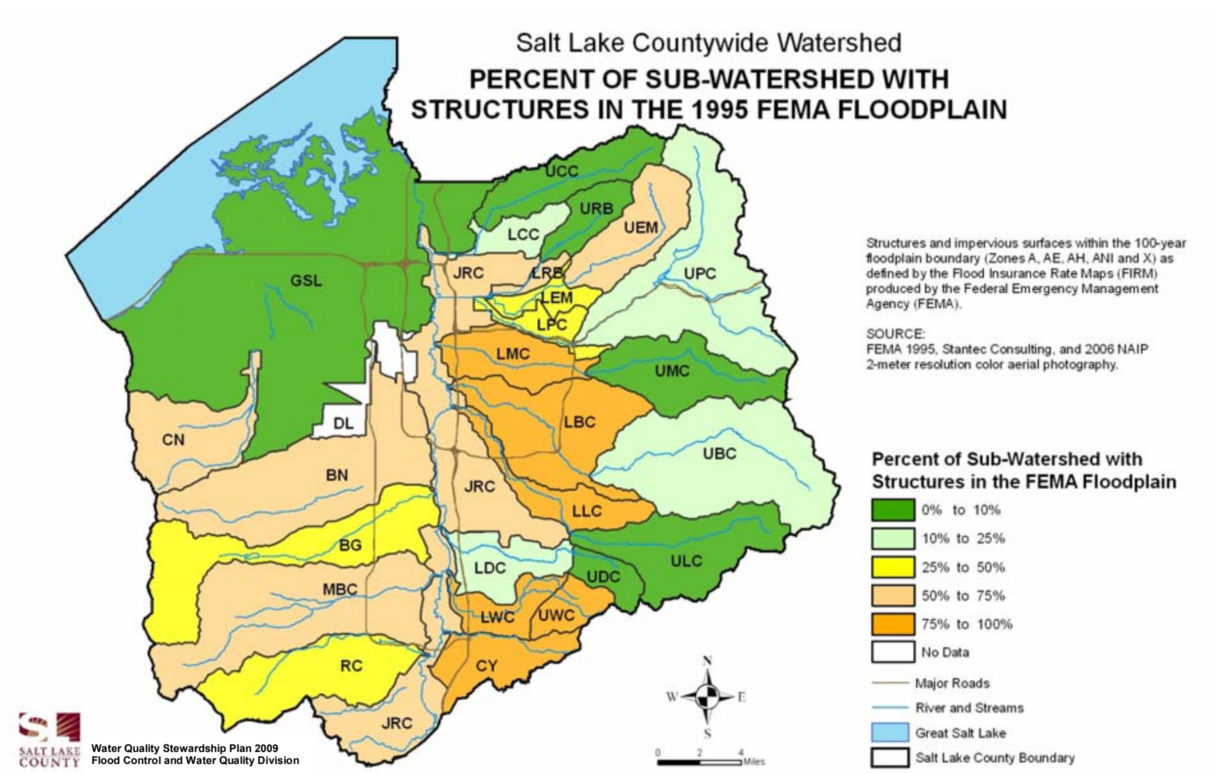


Figure 3.11.2 Structures in FEMA Floodplain

3.12 Habitat

The area or type of environment in which populations of diverse organisms live or occur is generally defined as habitat. Elevation, geography and topography, climate, and vegetation typically define habitat types. Although roughly one-third (1/3) of Salt Lake County is occupied by urban development, significant habitat resources for terrestrial, aquatic, and avian life forms remain and flourish within natural, or mainly undeveloped, waterways and sub-watersheds.

Significant density and diversity of mammalian wildlife species have been documented for both the Wasatch Canyon and Oquirrh ecological complexes (DWR, 2007). Important game habitat has been identified and mapped for black bear, desert bighorn sheep, elk, mule deer, snowshoe hare, mountain goat, and moose. Important avian game species include wild turkey, band-tailed pigeon, blue grouse, chukar, california quail, hungarian partridge, ring-necked pheasant, ruffed grouse, and sage grouse.

In addition to the game birds, over 177 species of passerine, sub-tropical migrants, raptor, and wading birds inhabit the headwaters regions of Brighton Basin (Upper Big Cottonwood Creek Sub-Watershed) and Parley's Park, (Upper Parley's Creek Sub-Watershed) (Robinson, 1962).

Vegetation communities form the basis for terrestrial habitat characterization. Dominant mountain vegetation complexes have been most

Residence adjacent to Little Cottonwood Creek, Lower Little Cottonwood Creek Sub-Watershed

Beaver Dam, Upper Big Cottonwood Creek Sub-Watershed

recently mapped and described by the United States Geological Survey's 2004 Gap Analysis Program, which identifies forty (40) elevational-based vegetation community types in Salt Lake County (Lowry et al., 2005). These include, but are not limited to; Foothill and lower Montane Woodland and Shrubland, Wet Meadows, Aspen Woodlands, Riparian Woodland and Shrubland, Dry-Mesic Conifer Forest Woodlands, Subalpine Mesic Meadows and Spruce-Fir Forest Woodlands. The Oquirrh Mountain range was similarly described (Kennecott Lands, 2007).

In the Great Salt Lake ecosystem complex near the south shore, the avian habitat vegetation communities were defined as part of the South Shore Special Area Management Plan (SAMP) (Salt Lake County, 2003). These communities included open water, mud flats, playas, wet meadows, emergent marshes, and transitional zones, and are recognized as an important element of the Northern Hemisphere migration and nesting habitat linkages for birds.

Additionally, habitat units were defined along the Jordan River corridor (9400-14600 South) by the Utah Division of Wildlife Resources (DWR) as part of a comprehensive terrestrial wildlife study for feasibility of dam construction (Smith Greenwood, 1984). This study identified the presence of seven (7) species of amphibians, fourteen (14) species of reptiles, fifty (50) species of mammals, and one-hundred and ninety (190) species of birds.

The vegetation communities supporting this relatively diverse wildlife population included alfalfa fields, grain fields, pasture-hay fields, deciduous woodlands, sagebrush-rabbitbrush, cattail-bulrush, mixed wetlands, willow strip cover, and waste areas. Later inventory supporting the Jordan River Wetland Advance Identification Study (WAIDS) included fishery and wildlife habitat data (Jensen, 1987).

An analysis was conducted to estimate the length of streams in the Watershed with adjacent land that is publicly owned or privately held with conservation protection. The streams and rivers were overlayed on the most recent Countywide parcel mapping (December 2007). Sections of stream overlapping any publicly owned parcel and any privately-owned parcel with obvious or known conservation protection were identified. Several parcels along the stream lacked ownership information and were identified only as unassessed for property tax purposes. These parcels were selected as being publicly owned including the corridor containing the Jordan River, which is held by the Utah Division of Forestry, Fire and State Lands. The sub-watersheds with the least publicly owned or conserved stream corridors are in the urban portion of the Watershed (Figure 3.12.1).

3.12.1 Habitat—Aquatic

The Utah Division of Wildlife Resources (DWR) classifies both game and non-game fisheries state-wide, and has developed fishery classifications for the Wasatch Canyons, Jordan River, Canyon tributaries, and other perennial streams in Salt Lake County (DWR, 2007). Although DWR focuses its priorities on coldwater game fishes, it recognizes warmwater game species and others for important food chain support. Furthermore, in accordance with the State Water Plan, the "character and quality of the riparian zone directly impacts the fishery resources in several ways. Riparian vegetation helps determine water temperature which in turn determines fish species, composition, population size, and influences the available nutrients" (DWR, 1997). The general definition of fishery classifications is summarized below:

- Class 1: Support highest quality fisheries, considered Blue Ribbon waters; typically outstanding natural, truly unique streams; accessible by automobile and floatable; game fish productivity very high.
- Class 2: Of great importance as Class I but may be limited by development.

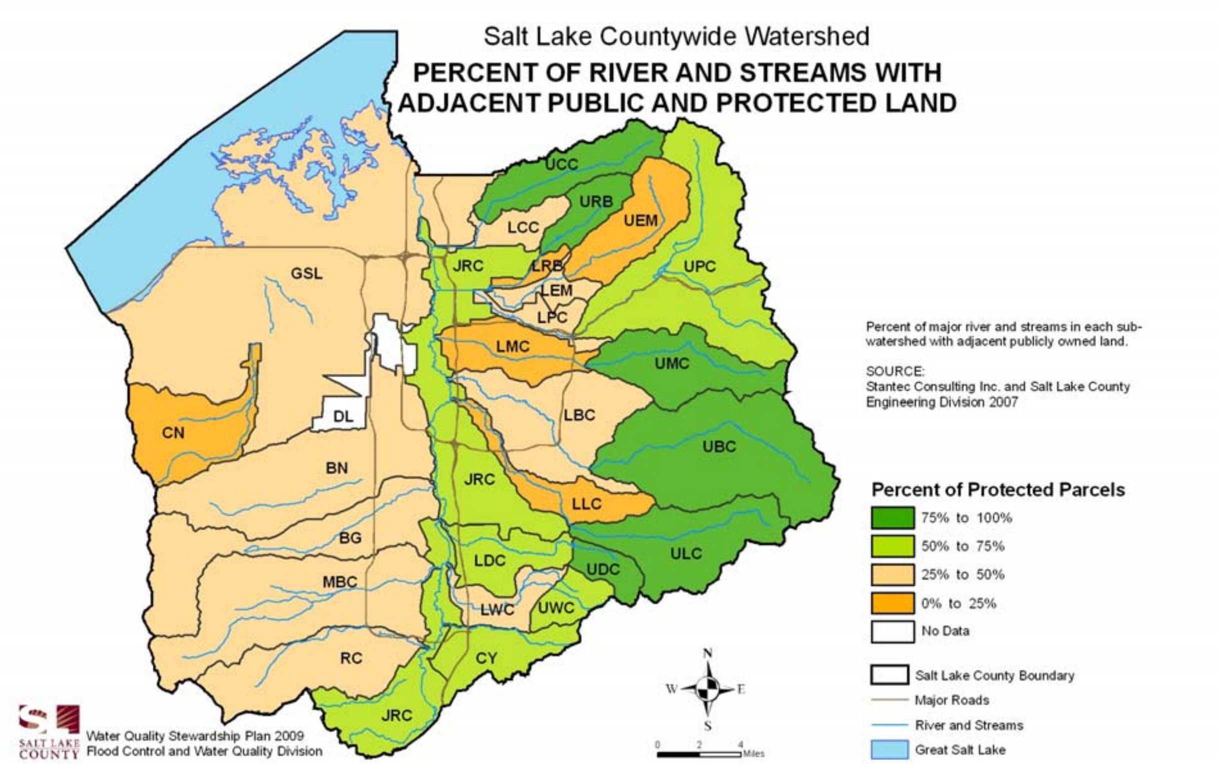


Figure 3.12.1 River and Streams with Adjacent Public Land

- Class 3: Important because they support the bulk of Utah stream fishing; fishery losses should be prevented or conditions enhanced when possible.
- Class 4: Typically poor in quality with limited sport fishery value, with fishing considered a secondary use; water development plans should propose enhancement of fishery values where feasible.
- Class 5: Streams in their present state are practically valueless as fisheries. However, many of these streams could produce valuable fisheries if additional water or physical habitat improvement provided.
- Class 6: Streams which are de-watered for significant periods of the year, but could provide good to excellent fish populations if minimum flows were provided.

Wasatch Mountain streams support populations of rainbow, cutthroat, and brook trout in the upper reaches. In the valley reaches of these streams, brown trout are often absent due to stream diversions and dewatering. Additionally, the fisheries in the lower reaches of the Wasatch Mountain streams are often affected by exchanges where clean, mountain waters are exchanged for irrigation waters which are primarily comprised of Utah Lake water. However, these reaches continue to support populations of brown trout, carp, Utah sucker, Mountain sucker, Longnose dase, and Utah chub. A study conducted by the Utah Division of Water Resources (DWRe) in 1997 found that the section of the Jordan River between Utah Lake and 9000 South supports the greatest variety of coldwater game fish. Downstream of 9000 South, the fishery is dominated by warm water species such as carp and Utah sucker (DWRe, 1997).

The Wasatch Mountain streams are classified as Class 3 in the headwater areas and have Class 4 and Class 5 sections in the lower portions (Figure 3.12.2).

Significant Jordan River fishery studies have been completed. During the development of the 1978 Area-wide Water Quality Management Plan, an examination of the fishery potential of the Jordan River was based on differing wastewater treatment alternatives (Way, 1980). Additionally, the Central Valley Water Reclamation Facility (CVWRF) conducted extensive Use Attainability Analyses, which concluded that 21 different species of fish inhabit the Jordan River at variable densities and locations. This study also found that the River is habitat limited as opposed to water quality limited for fish (Holden and Crist, 1987). Ominivores such as carp and sucker continue to dominate the commonly dredged, trapezoidal, sand/gravel channel reaches of the Jordan River. The DWR reflected those conclusions during the Jordan River Wetland Advance Identification Study (WAIDS). This study, as well as a study by Biowest (Wilson, 1987), concluded that while flow and quality were adequate, habitat diversity was generally a limiting factor.

Food chain support (benthic aquatic organisms or macroinvertebrates) for the Jordan River fishery has also been addressed with several studies over the last 50 years, beginning with Gaufin tracking 11 organism Orders (1957), and followed with comparative analysis of 12 Orders by Hinshaw (1966). The first comprehensive assessment of the Jordan River by the Environmental Protection Agency (EPA)

Mill Creek, Upper Mill Creek Sub-Watershed

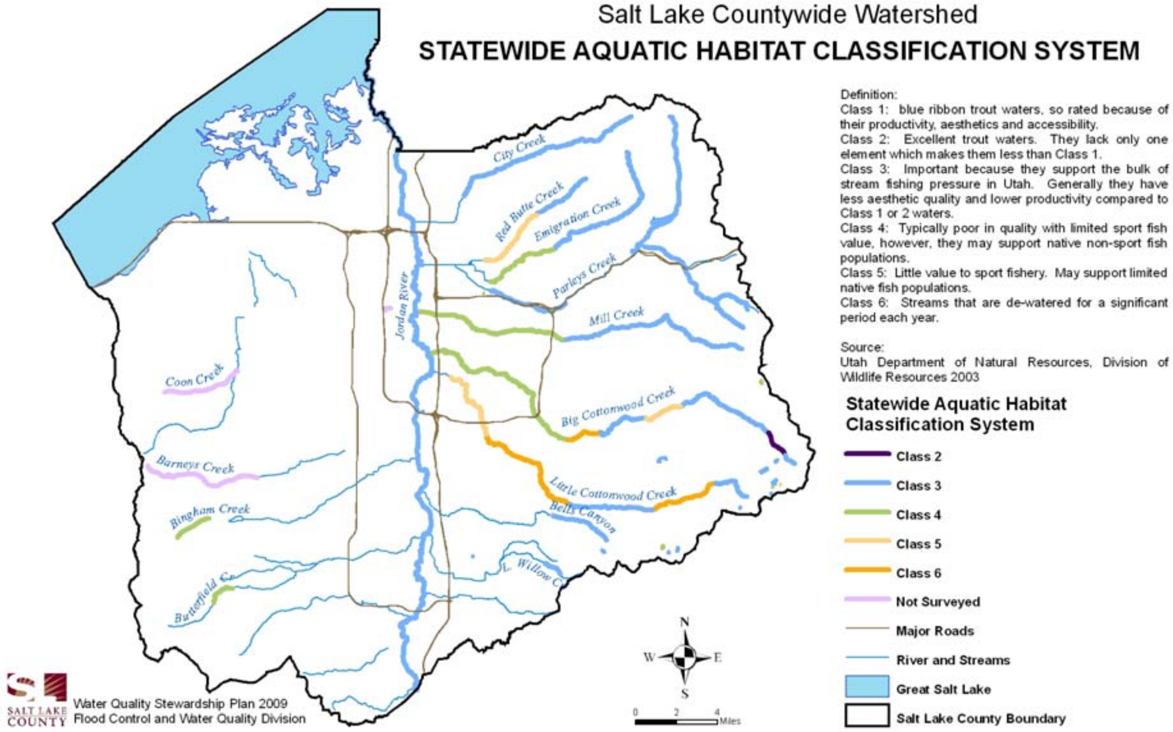


Figure 3.12.2 Statewide Aquatic Habitat Classification System

identified 14 Orders at 22 River stations (EPA, 1973). Subsequent studies for the EPA were conducted by Mangum (1986) and Salt Lake County (WAIDS) (Holden and Crist, 1987). In all studies, the majority of organisms (density and diversity), occur upstream of 3300 South, and downstream of 14600 South. The occurrence of benthic organisms also seems to follow geomorphic habitat conditions of the Jordan River from a higher gradient, sand/gravel dominated, erosive stream (upstream of 3300 South), to a lower gradient, sand/silt dominated depositional stream (downstream of 3300 South).

Food chain support for game fishes has been documented less in the high quality waters of the Jordan River tributaries and in the Wasatch Canyons. The U.S. Forest Service has documented trend density and diversity for Little Cottonwood, Big Cottonwood and Mill Creek in successive comparative analyses over 10-15 years. More recent comparative analyses in Red Butte and Emigration Creeks have been conducted by the U.S. Geological Survey (Giddings, 2000).

3.12.2 Habitat—Riparian Habitat

Riparian vegetation is a unique plant community that grows adjacent to rivers, streams, creeks, lakes and ponds. Riparian vegetation provides stream buffering and performs functions important to wildlife and humans alike. These values include groundwater recharge, groundwater discharge, flood storage, shoreline anchoring, sediment trapping, pollutant interception and storage, food chain support, fish and wildlife habitat, and recreation.

Riparian vegetation communities often extend well past the streams and lakes they protect. Since most riparian vegetation is rhizomatus (i.e. extending rhizomes for plant propagation), some plants can spread into areas with deeper water tables. For example, it is common to encounter cottonwood tree communities in areas with seasonal high water tables ranging from three to six (3-6) feet. Such trees can also survive seasonal saturation at the surface or within twelve (12) inches of the surface, typical of wetland hydrology. Other rhizomatus trees, such as Russian Olive, cannot tolerate long periods of shallow seasonal saturation and will not survive. They are, however, dominant members of the riparian communities in

Salt Lake County, and are well adapted to water table conditions deeper than three (3) feet from the surface. It is important to make the distinction that some riparian communities may be considered wetlands, depending on the boundary of seasonal flooding or saturation.

Another important distinction about riparian plant communities is that they are not limited to trees. Many riparian areas are dominated by scrub-shrub species such as willows, red osier dogwood, and wild rose. Other riparian areas are grasslands and wet meadows.

3.12.3 Habitat—Occurrence of Riparian Zones in Salt Lake County Sub-Watersheds

Riparian vegetation zones in the Salt Lake Countywide Watershed occur in three (3) general areas. These include the Great Salt Lake South Shore, Jordan River corridor, and mountain areas of the Wasatch & Oquirrh Canyons.

The Wasatch Canyons display a wide variation of riparian vegetation communities dependent mainly on elevation. Elevation divisions typically include Foothill, Lower Montane, Mid-Montane, Upper Montane, Sub-Alpine, and Alpine (Lowry, 2005). The vegetation units described within each of these generally includes definitions of wet meadows, mesic meadows, shrublands, woodlands, and forest, and these vegetation units often define riparian corridors along first, second and third order streams.

For example, Big Cottonwood Creek is a third order stream, the Silver Fork tributary is a second order stream, and the headwater tributaries to Silver Fork are first order streams. All of these stream orders possess riparian corridors, many of which are wetland. Due to this complex relationship typical of the Rocky Mountain Region, it would be inaccurate to describe riparian areas confined only to Big Cottonwood Creek. The U.S. Forest Service has described extensive riparian community types in Utah and Southeastern Idaho that reflect mixes of both upland, mesic, and wetland species which occur often in streamside or meadow riparian corridors (Padgett, Youngblood & Winward, 1989).

Furthermore, glacial history has left remnant “tarns” or glacial lakes in headwaters, which may exhibit a wide variety of vegetation communities, including

Red-Breasted Nuthatch

oligotrophic, eutropic, and late successional conditions (Windell, et al., 1986) and are hydrologically connected to springs, seeps, or ephemeral streams seasonally discharging downstream.

Due to urban development the Jordan River Valley, is much less complex in its riparian corridor community, and many of the streamside vegetation communities have been destroyed by grazing, channelization, piping, or residential/ commercial/industrial land use encroachment. Here, the riparian corridor is often defined by the floodplain or floodway of the individual stream or creek, and reflects altered or disturbed conditions that influence the vegetative cover type. The valley sections of the tributaries to the Jordan River and the Jordan River itself, often meet requirements of the Invasive Southwest Woodland and Shrubland cover type, that includes Cottonwood, Tamarix, Russian Olive, Coyote Willow, and other wetland overstory trees or shrubby species. Due to the arid nature of the Jordan Valley, riparian communities also include those plants identified in the North American Warm Desert or Great Plains Riparian Woodland and Shrubland, and Western Great Plains Floodplain. Various species of cottonwood and willow comprise this community “dependent upon annual or periodic flooding and associated sediment scour and/or annual rise in the watertable for growth and reproduction (Lowry, 2005).

The Great Salt Lake Southern shoreland has been described in numerous studies over the last 35 years, including the South Shoreland Special Area

Riparian vegetation along the Jordan River, Jordan River Corridor Sub-Watershed

Management Plan, National Wetland Inventory, and USGS Gap Analysis. This area meets the functional requirements of a riparian plant community, with little or no overstory (tree) presence, and dominated by shrubby species and invasive grasslands. Included in this category (Lowry, 2005) would be Inter-mountain Basin Mixed Salt Desert Scrub, Greasewood Flats and Playas, and Semi-Desert Grasslands. Recent hydro-geomorphic classification efforts by the Army Corps of Engineers would include Saline Depression Wetlands in this sub-region. Water quality and flow regimes in the Jordan River may have significant effects on the wetlands associated with the Great Salt Lake.

3.12.4 Habitat—Wetlands

Wetlands are "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas," (Environmental Laboratory, 1987).

Wetland vegetation consists of plants typically adapted to saturated hydrologic conditions and persist in anaerobic (low oxygen) soils. Wetland vegetation is categorized broadly as facultative (occurring in wetlands 50% of the time), facultative wet (occurring in wetlands 65% of the time), and obligate (occurring in wetlands 95% of the time).

Wetlands are regulated under Section 404 of the Federal Clean Water Act, and require a permit from the Army Corps of Engineers when activities are planned to destroy, modify, or re-locate jurisdictional wetlands.

Due to the lack of public information, education, and confusion over what constitutes a wetland, and how they are managed, EPA Region VIII funded the first "Wetland Advance Identification Study" in the Intermountain West along the 25-mile segment of the Jordan River, in 1984. This study identified approximately 2,000 acres of wetlands along the Jordan River and provided the basis for wetland acquisition efforts in the mid-1990's (Jensen, 1987). Additional advance identification projects were subsequently funded by the EPA, Town of Alta, and Salt Lake County in Little Cottonwood Canyon's Albion Basin (Upper Little Cottonwood Creek Sub-Watershed) (Crowley, 1992; Jensen, 1993), and Big Cottonwood Canyon's Brighton Basin (Upper Big Cottonwood Creek Sub-Watershed) (Jensen, 2000).

Subsequent studies of wetlands associated with the South Shore of the Great Salt Lake were conducted by the U.S. Fish & Wildlife Service (NWI, 1980), Salt Lake County (West, 1984), and the South Shore Special Management Plan team (Salt Lake County, 2003).

Wetlands commonly occur along perennial, intermittent, and ephemeral water courses in the Wasatch Mountains. Intermittent streams are defined as those streams that flow for a portion of the year or seasonally. Perennial streams have instream flow continuously throughout the year and ephemeral streams are watercourses that carry water only during and/or immediately following

Typical wetland vegetation, Jordan River Corridor Sub-Watershed rainstorms. In addition to occurring along watercourses, wetlands exist within glacial depressions and meadows in the Wasatch Mountains. The U.S. Forest Service identified numerous wetland community types previously classified only as riparian (Padgett et al., 1989). Along the Salt Lake Valley tributaries, wetlands commonly occur below Wasatch Fault displacement zones or discharge zones created from springs originating in the shallow unconfined aquifer (Salt Lake County, 1981).


Wetland area along Midas Creek, Midas/Butterfield Creek Sub-Watershed

Wetlands are of critical importance to water resources planning efforts of all types, due to the functional values they possess. These include groundwater recharge, groundwater discharge, flood storage, shoreline anchoring, sediment trapping, nutrient & pollutant retention, food chain support for a host of birds and animals, fish and wildlife habitat, and recreation.

Future planning should include efforts to identify and classify priority wetlands in the Salt Lake Countywide Watershed and develop funding programs for protection, conservation and acquisition.


Riparian vegetation along Harker's Creek, Coon Creek Sub-Watershed

3.13 WATER QUALITY

The State of Utah Division of Water Quality (DWQ) determines beneficial use classifications for streams, rivers, lakes and reservoirs in the State. In addition to narrative water quality standards (R317-2-7.2, UCA), specific water quality numeric criteria for pollutants are associated with each beneficial use class (R317-2-7.1, UCA). Therefore, the amount of a pollutant that a given waterbody can contain and still meet the water quality standards is determined by its beneficial use. Utah DWQ is responsible for designating beneficial uses and monitoring water quality for all waters in the State. Water quality data obtained is compared with the criteria to determine whether or not the designated beneficial uses are supported and standards are being met. This information is used to identify impaired waterbodies and in Total Maximum Daily Load (TMDL) analyses.

Beneficial use designations are organized by class and are grouped according to type of use (Table 3.13.1).

The Salt Lake Countywide Watershed contains seven (7) distinct beneficial use categories (Figure 3.13.1). The majority of the valley and the northwest areas of the County are undefined, which is due to the lack of surface waters in these areas. The streams in the large eastern sub-watersheds are categorized as 1C, 2B, and 3A waters – these designations support drinking water protection, secondary contact recreation, and coldwater fisheries. Mill Creek, the upper reaches of the Jordan River, and the lower sub-watersheds of both Big and Little Cottonwood Creeks support 2B, 3A, and 4 beneficial uses. Emigration Creek and the lower section of City Creek contain 2B and 3A waterbodies – these designations require water quality sufficient to support secondary contact recreation and coldwater fisheries. A large section in the southwestern portion of Salt Lake County supports 2B, 3D, and 4 beneficial uses – secondary contact, waterfowl, and agriculture. The middle reaches of the Jordan River support 2B, 3B, and 4 beneficial uses – supporting secondary contact recreation, warm water fishery, and agricultural use. The lower reaches of the Jordan River are

Table 3.13.1 Designated Beneficial Uses

Class	Definition
Class 1	**Protected for use as a raw water source for domestic water systems**
Class 1A	Reserved
Class 1B	Reserved
Class 1C	Protected for domestic purposes with prior treatment by treatment processes as required by the Utah Division of Drinking Water
Class 2	**Protected for recreational use and aesthetics**
Class 2A	Protected for primary contact recreation such as swimming
Class 2B	Protected for secondary contact recreation such as boating, wading, or similar uses
Class 3	**Protected for use by aquatic wildlife**
Class 3A	Protected for cold-water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain
Class 3B	Protected for warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain
Class 3C	Protected for non-game fish and other aquatic life, including the necessary aquatic organisms in their food chain
Class 3D	Protected for waterfowl, shore birds and other water-oriented wildlife not included in Classes 3A, 3B, or 3C, including the necessary aquatic organisms in their food chain
Class 3E	Severely habitat-limited waters. Narrative standards will be applied to protect these waters for aquatic wildlife
Class 4	**Protected for agricultural uses including irrigation of crops and stock watering**
Class 5*	**Great Salt Lake** Protected for primary and secondary contact recreation, aquatic wildlife, and mineral extraction
*Class 5 is a special classification given only to the Great Salt Lake indicating that the Lake is protected for primary and secondary contact recreation, aquatic wildlife, and mineral extraction (however, there are no water quality standards associated with this beneficial use).	

Source: UAC Rule R317.2

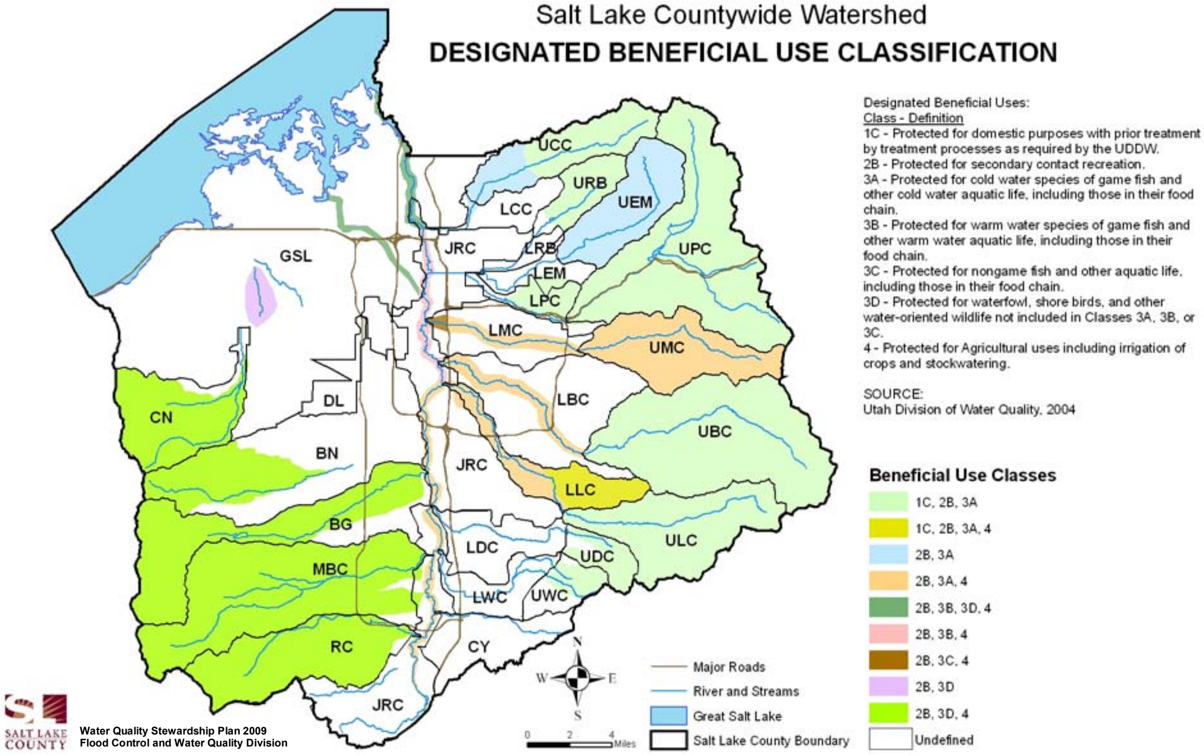


Figure 3.13.1 Beneficial Use Classes

designated as class 2B, 3B, 3D, and 4 beneficial uses, supporting secondary contact recreation, warm water fisheries, waterfowl and wildlife, and agricultural uses.

The DWQ uses a 5-year rotating monitoring process to assess the State's waterbodies. DWQ utilizes data obtained from the Division's cooperative monitoring program (including several federal agencies), the USGS's National Water Quality Assessment (NAWQA) Program, Salt Lake City and Salt Lake County. The development of the monitoring program includes input from the following State programs:

- Nonpoint Source Pollution 319 Program
- TMDL/Watershed Planning Program
- Point Source Program
- Stormwater Program
- Groundwater Protection Program

The 2006 305(b) (DWQ, 2006) assessment includes a summary evaluation of the intensive monitoring surveys for the Jordan River Watershed Management Unit. Determining support of beneficial uses utilized chemical, physical, and biological data, as well as other information collected by DWQ.

3.13.1 Water Quality—Anti-Degradation Policy

Certain waterbodies in the State of Utah have been designated as "High Quality Waters" in accordance with the Utah Administrative Code Rule R317.2, Standards of Quality for Waters of the State, Section R317-2-3 Antidegradation Policy. High Quality Waters - Category 1 are waters of high quality with exceptional recreational or ecological significance, or that require protection. New point source discharges are prohibited in these segments, and diffuse sources are controlled to the extent feasible through implementation of best management practices or regulatory programs.

Waterbodies in the Jordan River Watershed that have been designated as High Quality Waters – Category 1 are identified in Table 3.13.2.

Table 3.13.2 Category 1 High Quality Waters

Sub-Watershed	Waterbody	Location
All surface waters located within the outer boundaries of U.S. National Forests		
Upper Dry Creek	Bell Canyon Creek	Bell Canyon Creek and tributaries from Lower Bells Canyon Reservoir to headwaters
Upper Big Cottonwood	Big Cottonwood Creek	Big Cottonwood Creek and tributaries from Wasatch Blvd to headwaters
Upper City Creek	City Creek	City Creek and tributaries from City Creek Water Treatment Plant to headwaters
Upper Dry Creek	South Fork of Dry Creek	South Fork of Dry Creek and tributaries from Draper Irrigation Company diversion to headwaters
Upper Emigration Creek	Emigration Creek	Emigration Creek and tributaries from Hogle Zoo to headwaters
Upper Mill Creek	Mill Creek	Mill Creek and tributaries from Wasatch Blvd to headwaters
Upper Parley's Creek	Parley's Creek	Parley's Creek and tributaries from 1300 East to headwaters
Upper Red Butte	Red Butte Creek	Red Butte Creek and tributaries from Foothill Blvd to headwaters
Upper Willow Creek	Little Willow Creek	Little Willow Creek and tributaries from diversion to headwaters

Source: UAC R317.2, 2006

3.13.2 Water Quality—Impaired Waterbodies

In accordance with guidance from the Environmental Protection Agency (EPA, 2006), the State of Utah is required to assess the quality of waters of the State to determine if pollution controls are stringent enough to meet state water quality standards. This evaluation includes compliance with the state water quality standards and impairment of beneficial uses.

The Utah 2006 Integrated Report (DWQ, 2006) lists impaired waterbodies in accordance with the categories provided in Table 3.13.3. In accordance with the DWQ classification system, Category 5 waters are considered to be on the 303(d) list. However, for the purposes of this report, a waterbody is determined to be water quality limited or impaired if listed as either a Category 4 or 5 (Table 3.13.4). Including the Category 4 waterbodies adds a segment of Parley's Creek and a segment of Little Cottonwood Creek to the impaired waterbody list. These particular waterbodies are not on the 303 (d) or Category 5 list, as they do not require a TMDL for the following reasons:

- Parley's Creek - the cause of impairment is not caused by a pollutant (i.e. habitat alteration)
- Little Cottonwood Creek - a TMDL has been completed

Figure 3.13.2 provides an analysis of the stream segments in the sub-watersheds that are impaired or categorized as Class 4 or 5 waters according to the DWQ. The sub-watersheds listed below are impaired by more than 66%. These impairments are primarily attributable to historic mining in these canyons, hydrologic modification, and increased pressure from urban development and recreational activities.

Big Cottonwood Creek, Upper Big Cottonwood Creek Sub-Watershed

Table 3.13.3 Assessment Categories

Category	Sub-Category	Definition
1	N/A	All designated uses are obtained
2	N/A	Some designated uses supported, insufficient data to determine remaining uses
3	N/A	Not assessed
4	N/A	Impaired - TMDL not required
	4A	TMDL completed for all pollutants
	4B	Other pollutant control requirements are reasonably expected to result in attainment of the water quality standard in the near future
	4C	Impairment is not caused by a pollutant (e.g. habitat alteration)
5	N/A	Water quality standard is not attained
	5A	Impaired, TMDL needed
	5B	Request for removal from 303(d) list for reasons other than an approved TMDL
	5C	UPDES permit limited (water impaired if effluent limits not met)
	5D	Lake or reservoir has been assessed as not meeting standards

Source: Utah DWQ 2006 Integrated Report, 2006

Table 3.13.4 Impaired Waterbodies in the Salt Lake Countywide Watershed

Waterbody	Stream Miles	Location	Cause of Impairment	Category Listing	Beneficial Use
Big Cottonwood Creek-1	9.52	Big Cottonwood Creek & tributaries from confluence to the water treatment plant	Temperature	5A	3A
Emigration Creek	4.29	Emigration Creek & tributaries from Foothill Blvd to headwaters	E.coli	5A	2B
Jordan River-1	6.30	Jordan River from Farmington Bay upstream contiguous with the Davis County line.	DO, TDS	5A	3B
Jordan River-2	4.46	Jordan River from Davis Co line upstream to N. Temple	E.coli, DO	5A	2B, 3B
Jordan River-3	4.20	Jordan River from N Temple - 2100 S	E.coli	5A	2B
Jordan River-5	1.63	Jordan River from 6400 S to 7800 S	E.coli, Temperature, TDS	5A	2B, 3A, 4
Jordan River-6	10.29	Jordan River from 7800 S to Bluffdale	Temperature, TDS	5A	3A, 4
Jordan River-7	4.18	Jordan River from Bluffdale to Narrows	Temperature, TDS	5A	3A, 4
Little Cottonwood Creek-1	8.73	Little Cottonwood Creek & tributaries from confluence to the water treatment plant	Temperature, TDS	5A	3A, 4
Little Cottonwood Creek-2	21.49	Little Cottonwood Creek & tributaries from the water treatment plant to headwaters	Zinc	4A	3A
Parley's Creek-1	11.38	Parley's Creek & tributaries from 1300 East to Mountain Dell Reservoir	Habitat Alteration	4C	3A

Source: Utah DWQ 2006 Integrated Report, 2006

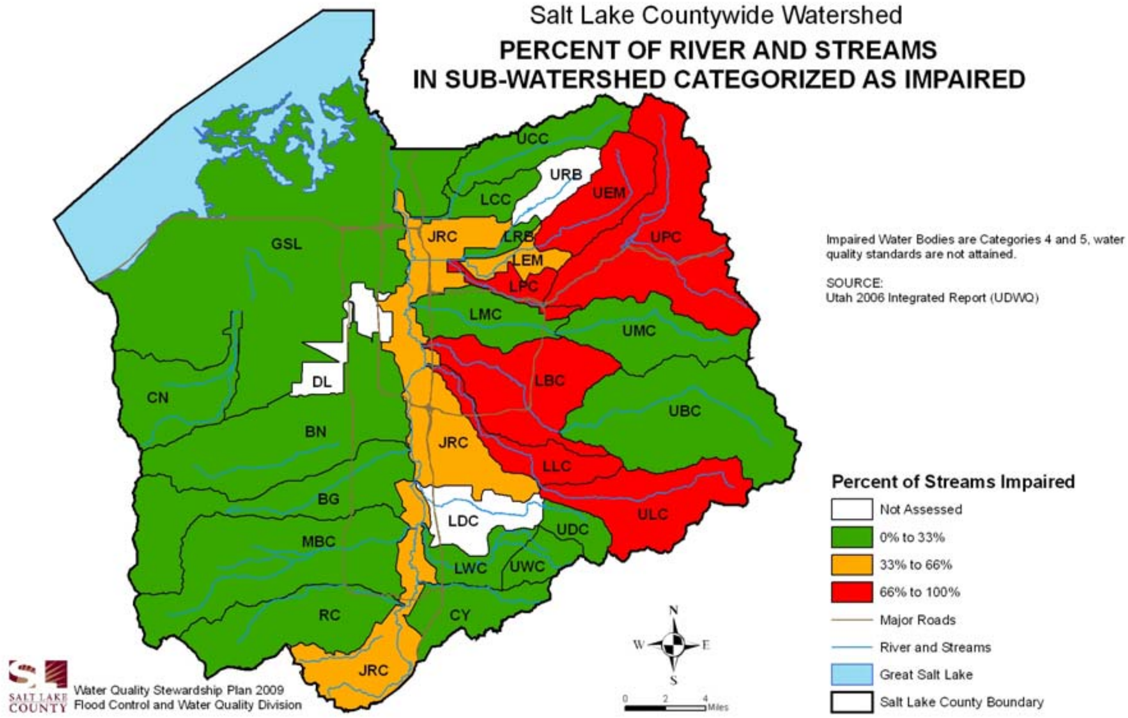


Figure 3.13.2 Impaired Waterbodies

- Lower Big Cottonwood Creek (LBC)
- Upper Emigration Creek (UEM)
- Upper Little Cottonwood Creek (ULC)
- Lower Little Cottonwood Creek (LLC)
- Upper Parley's Creek (UPC)
- Lower Parley's Creek (LPC)

3.13.3 Water Quality—Water Quality Trend

Water quality trend analyses were conducted on two (2) constituents: Total Phosphorus (TP) and Total Dissolved Solids (TDS). TP was selected as it is known to contribute to low Dissolved Oxygen (DO) conditions in waterways, which can negatively impact fisheries habitat. Excess TP can promote abundant phytoplankton and algal growth, the decomposition of which results in reduced DO in the waterway. TDS was selected as it is generally a constituent of concern in Salt Lake County and is a general indicator of the presence of chemical contaminants. TDS refers to the combined content of organic and inorganic substances in dissolved form in a liquid. The most common chemical constituents are calcium, phosphates, nitrates, magnesium, sodium, potassium and chloride. TDS is considered a conservative substance that is not subject to chemical reactions or transformations that change the concentration.

Sampling stations along the tributaries in each sub-watershed with long-term monitoring (greater than 15 years) of TP and TDS were selected for this trend analysis. Historical TP and TDS levels were graphed and the mean annual change in concentration was calculated for each of these parameters using a linear regression analysis. The mean annual change in concentrations may be used to indicate historical trends in water quality. However, twelve (12) of the twenty-seven (27) sub-watersheds had insufficient data to perform this analysis.

The concentration of constituents can vary with the amount of flow and therefore the results of the trend analysis can be biased by droughts or long periods of wet weather. A correlation analysis between TP and TDS versus flow rate was conducted at selected sampling sites. The analysis suggested no correlation between TP and flow rate, whereas TDS was inversely proportional to flow rate. Salt Lake County generally experienced drought conditions in the early 2000's; therefore, it would be expected that TDS concentrations would be greater than normal during this period.

The mean annual change for TP was very small, ranging from –0.000113 to 0.000010 mg/L (Table 3.13.5). This indicates that mean TP concentration was stable over the period of record. Upper Parley's Creek (UPC) and Lower Big Cottonwood Creek (LBC) sub-watersheds showed a slight increase in TP, while the remaining sub-watersheds showed a slight decrease. Despite the stable levels, mean concentration of TP was at or above the state water quality indicator standard of 0.05 mg/L in 11 of the 15 Sub-Watersheds with sufficient historical sampling data. The mean concentration was particularly high in the Jordan River at 2100 South and Cudahy Lane (1.19 and 0.92 mg/L, respectively).

The results of the TDS trend analysis are presented in Figure 3.13.3. The mean annual change for TDS concentration was greater than for TP, ranging from –0.0093 to 0.0746 mg/L. Upper Parley's Creek (UPC) and Midas/Butterfield Creek (MBC) Sub-Watersheds showed a decrease in TDS, while the remaining sub-watersheds showed an increase. The TDS results can be partially explained by the lower flows in the early 2000's, which would be expected to result in higher concentrations of TDS. However, the mean annual concentration of TDS was generally well below the state water quality standard of 1,200 mg/L for agricultural use, but above the secondary drinking water standard of 500 mg/L. The Jordan River had the highest mean concentration of TDS, ranging from 888 to 950 mg/L.

These results indicate that water quality in Salt Lake County, as measured by TP and TDS, has not significantly degraded based on historical water quality sampling. However, the mean TP concentration was generally above the state indicator water quality standard. The southeastern and southwestern streams, which have experienced a high rate of growth, generally do

Table 3.13.5 Water Quality Trend Results

		Total Phosphorus			Total Dissolved Solids		
Sub-watershed	Sampling Station Number	Mean Annual Change (mg/L)	Number of Samples	Mean Conc. (mg/L)	Mean Annual Change (mg/L)	Number of Samples	Mean Conc. (mg/L)
Upper Big Cottonwood Creek	4993100	-0.000051	267	0.16	0.0024	320	171
Lower Big Cottonwood Creek	4992970	0.000010	55	0.12	0.0113	59	571
Upper City Creek	4991950	0.000000	152	0.02	0.0033	171	223
Upper Emigration Creek	4992160	-0.000003	137	0.04	0.0404	146	458
Lower Emigration Creek	4992140	-0.000001	90	0.05	0.0160	102	562
Jordan River—Bluffdale Road	4994600	-0.000004	215	0.09	0.0211	232	950
Jordan River—2100 South	4992320	-0.000113	62	1.19	0.0084	63	918
Jordan River—Cudahy Lane	4991820	-0.000018	258	0.92	0.0180	250	888
Upper Little Cottonwood Creek	4993660	-0.000001	261	0.02	0.0036	309	134
Lower Little Cottonwood Creek	4993580	-0.000006	42	0.08	0.0581	40	772
Midas/Butterfield Creek	4994440	-0.000012	37	0.06	-0.0093	60	580
Upper Mill Creek	4992640	-0.000004	263	0.04	0.0048	307	380
Lower Mill Creek	4992540	-0.000026	44	0.12	0.0279	44	655
Upper Parleys Creek	4992170	0.000001	138	0.05	-0.0010	146	603
Lower Parleys Creek	4992230	-0.000015	62	0.02	0.0746	64	722
Upper Red Butte Creek	4992100	-0.000004	70	0.03	0.0041	80	389
Lower Red Butte Creek	10172200	-0.000002	217	0.05	NA	NA	NA

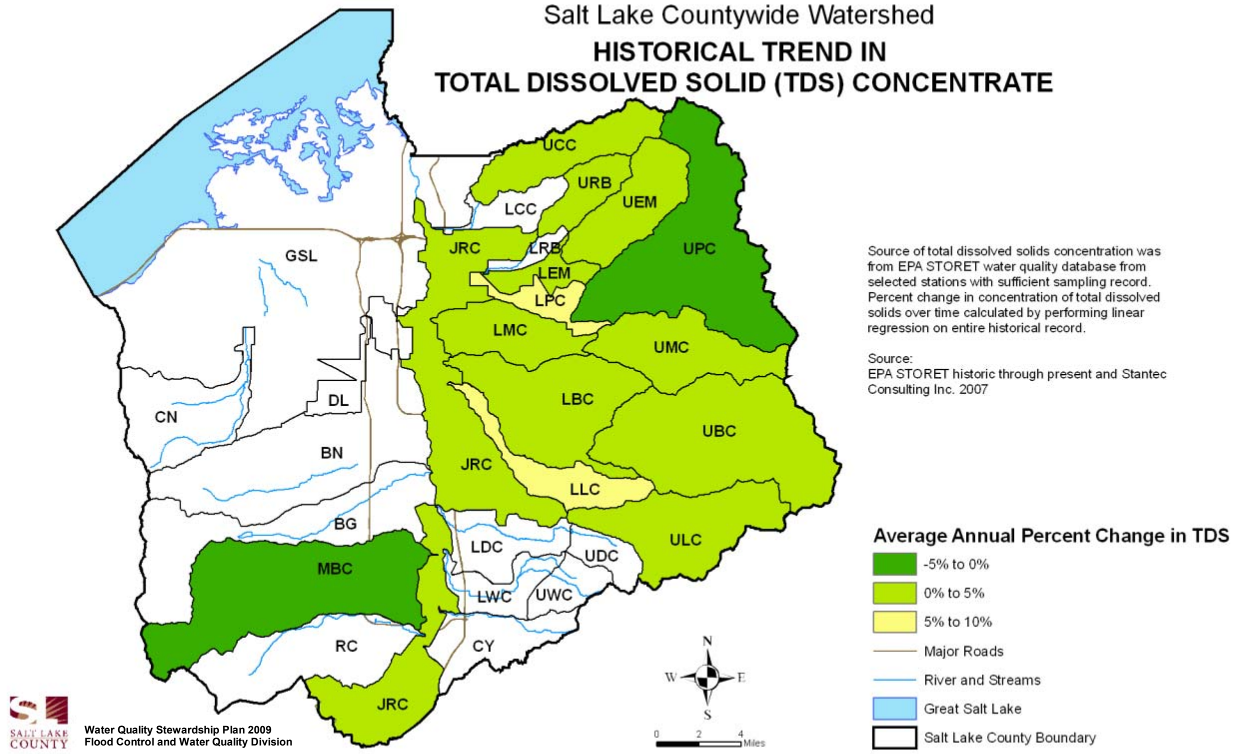


Figure 3.13.3 Historical Trend in Total Dissolved Solids

not have sampling data, therefore, trends in that area cannot be determined without further sampling.

3.13.4 Water Quality—Stormwater Pollutant Loads

An estimate of stormwater pollutant loading is an important component in the characterization of a watershed. This estimate will serve to develop management strategies in an effort to target load reductions and help improve water quality. Stormwater pollutant loads were estimated for three (3) constituents: Total Phosphorus (TP), Total Nitrogen (TN), and Total Suspended Solids (TSS).

Phosphorus and nitrogen were selected because they are the principal nutrients of concern in urban stormwater runoff (EPA, 1999). High levels of TP and TN can be harmful to water quality, causing excess growth of algae and lowered DO levels.

TSS was selected as it is a common contaminant in urban stormwater (EPA 1999). Elevated levels of TSS increase turbidity, causing conditions that are less suitable for recreation, fish habitat, and plant growth. Solids that settle out as bottom deposits can also cause problems in fish bearing streams by smothering eggs and destroying habitat for insects. Furthermore, other pollutants, such as oils and metals, often bind to sediments, causing further degradation to water quality.

Several watershed models are available to estimate stormwater pollutant loading. These models range from quite simple to very complex, which can be costly as well as time intensive. Export coefficients (the typical amount of a given pollutant being contributed by a specific land use category) used for this type of analysis are available from various parts of the nation. However, export coefficients vary greatly depending upon site-specific environmental conditions including precipitation and soils.

In order to capture local environmental conditions, stormwater quality data was used to estimate stormwater pollutant loading rates in Salt Lake County. Export coefficients for TP, TN and TSS were calculated based on the relationship between local historic data and land use categories.

Salt Lake County estimates annual stormwater pollutant loading rates based on data from six (6) sampling stations (Figure 3.13.4). The loading rates from these stations were associated with the land use categories represented by each station (Table 3.13.6). These loading rates were then applied to both current (2005) and future (2030) land use data. Subsequently, the total pollutant loading rate for each constituent in each sub-watershed was calculated. The following data manipulations were employed to capture pollutant loading rates in the County:

1. The County Mixed Use land use pollutant loading data was applied to the WaQSP Open and Public land use categories.
2. The pollutant loading data from the two (2) County residential land use stations (LIT06 & MIL07) were averaged to characterize the residential land use category.
3. Local data for pollutant loads from forested areas was not available; therefore, for this analysis, the open space land use was applied to the forest areas.

Pollutant loading rates based upon land use categories were used to estimate change in loading rates as a result of changes from current to future land use. Figures 3.13.5, 3.13.6 and 3.13.7 present the estimated percent change in TP, TSS, and TN loading rates, respectively, for each sub-watershed. The results of this analysis varied, showing both increases and decreases in the loading rates of the three (3) constituents. The percent change in pollutant loading rates are identified in Table 3.13.7.

The increases in loading rates are most likely attributed to a projected change in land use from forested or open space to residential or commercial. Loading rates typically increase when impervious surface area increases. It is noted that several sub-watersheds indicated either a minor increase or a decrease in some constituent loading rates. Therefore, while this information may be of use on a sub-watershed basis when identifying opportunities for watershed projects, the accuracy of these analyses must be taken into consideration.

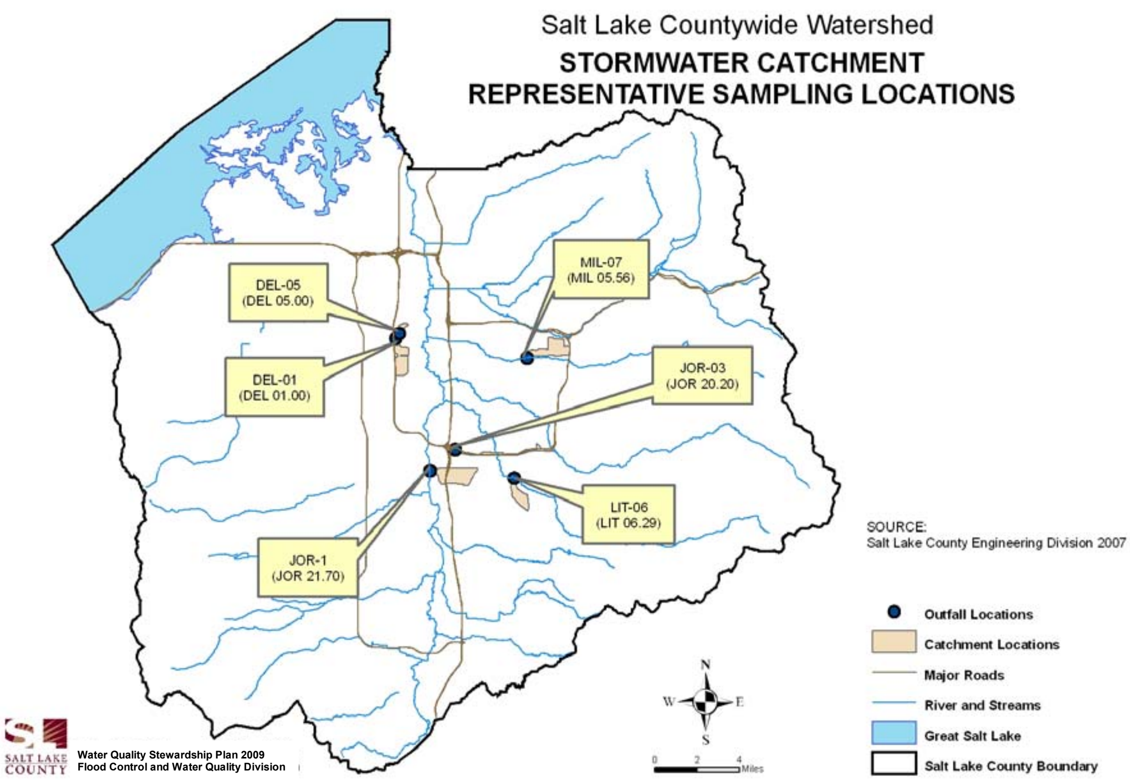


Figure 3.13.4 Stormwater Catchment Representative Sampling Locations

Table 3.13.6 Salt Lake County Stormwater Pollutant Loading Rates

Station ID	Receiving Water	Land Use	Pollutant Loading Rates (lb/acre/year)		
			TP	TN	TSS
DEL01	Decker Lake	Commercial	0.33	0.32	6.38
DEL05	Decker Lake	Industrial	0.42	0.42	8.46
JOR01	Jordan River	Mixed Use*	0.84	0.25	21.43
JOR03	Jordan River	Transportation	0.83	0.25	21.25
LIT06	Little Cottonwd Creek	Residential	0.46	0.19	5.22
MIL07	Mill Creek	Residential	0.67	0.28	9.93

**Mixed use includes open space and public land uses.*
Source: Salt Lake County, 2006

3.13.5 Water Quality—Pollutant Discharges

EPA has delegated authority to the Utah DWQ to administer its own water quality regulatory programs. In accordance with Utah Administrative Code R317.8, the State of Utah issues permits for the discharge of waters from point sources into waters of the State; however, the receiving waters must meet water quality standards and criteria set forth by DWQ.

The State of Utah issues Utah Pollutant Discharge Elimination System (UPDES) permits that set effluent pollutant limitations for industrial and municipal wastewater facilities, and federal facilities. UPDES permits are also issued for stormwater discharges from industrial and municipal sources (industrial stormwater includes stormwater from construction sites).

UPDES permits are written specific to the type of discharge, and may include numeric and narrative

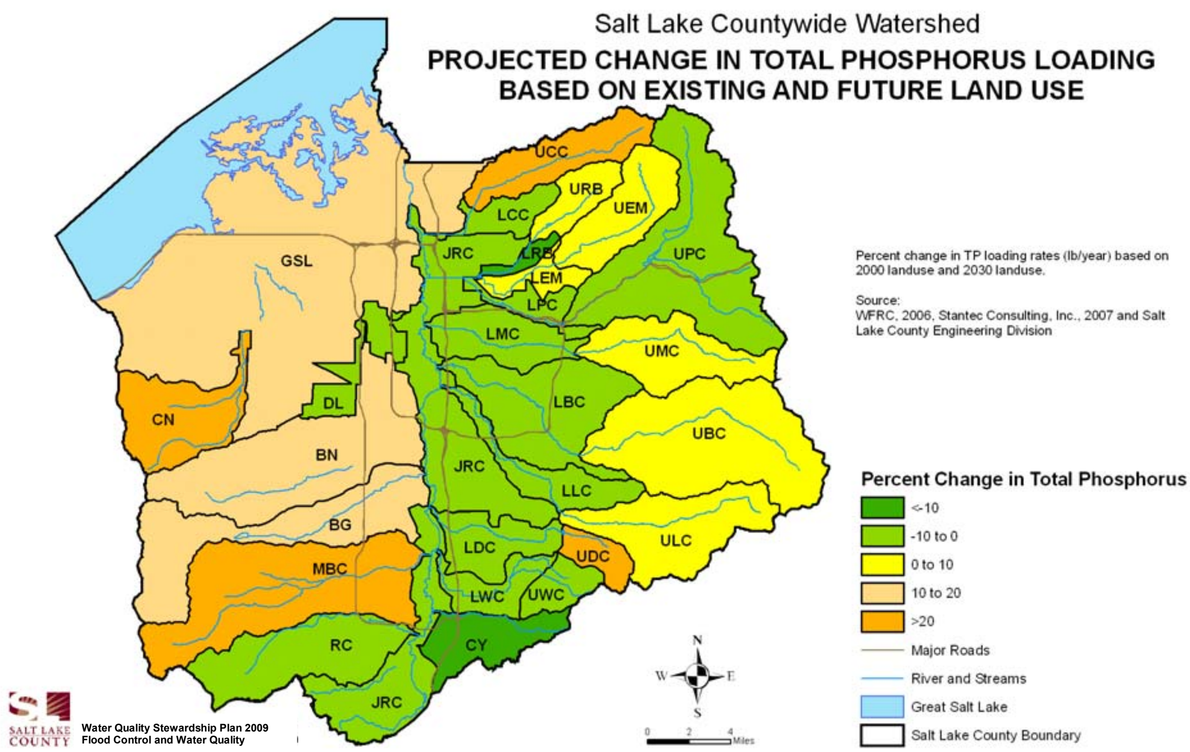


Figure 3.13.5 Projected Change in Total Phosphorus Loading

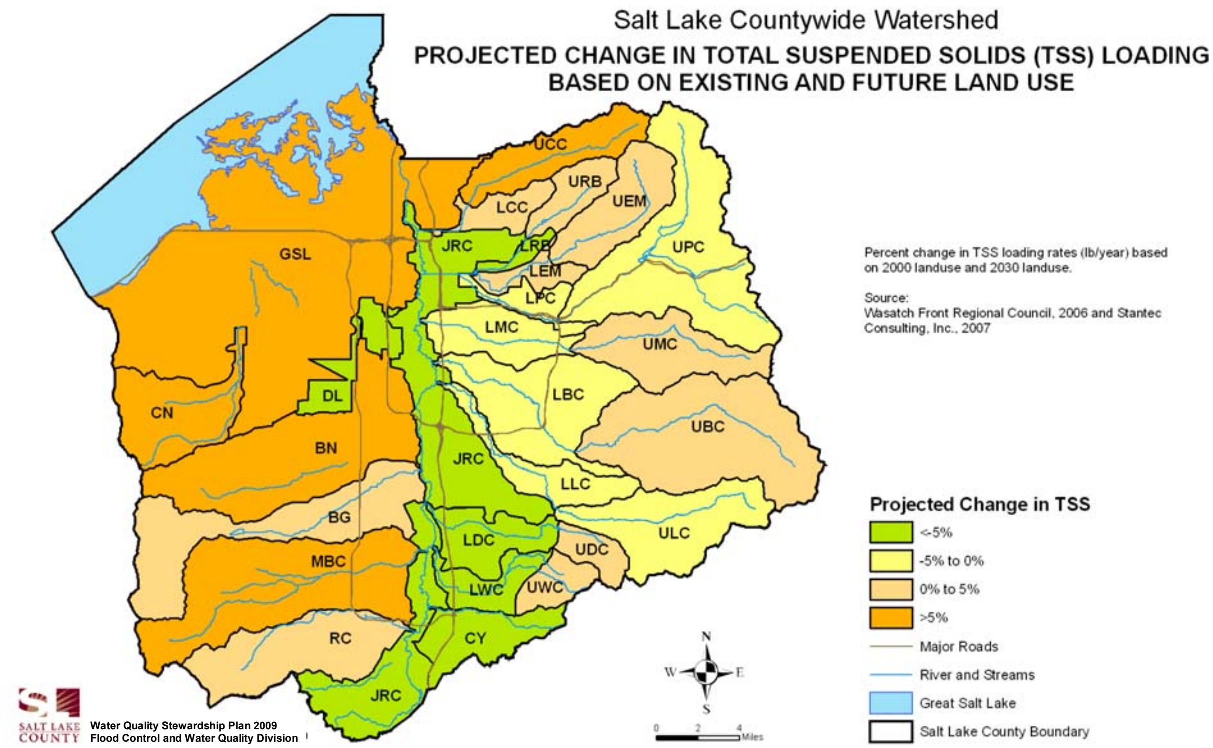


Figure 3.13.6 Projected Change in Total Suspended Solids Loading

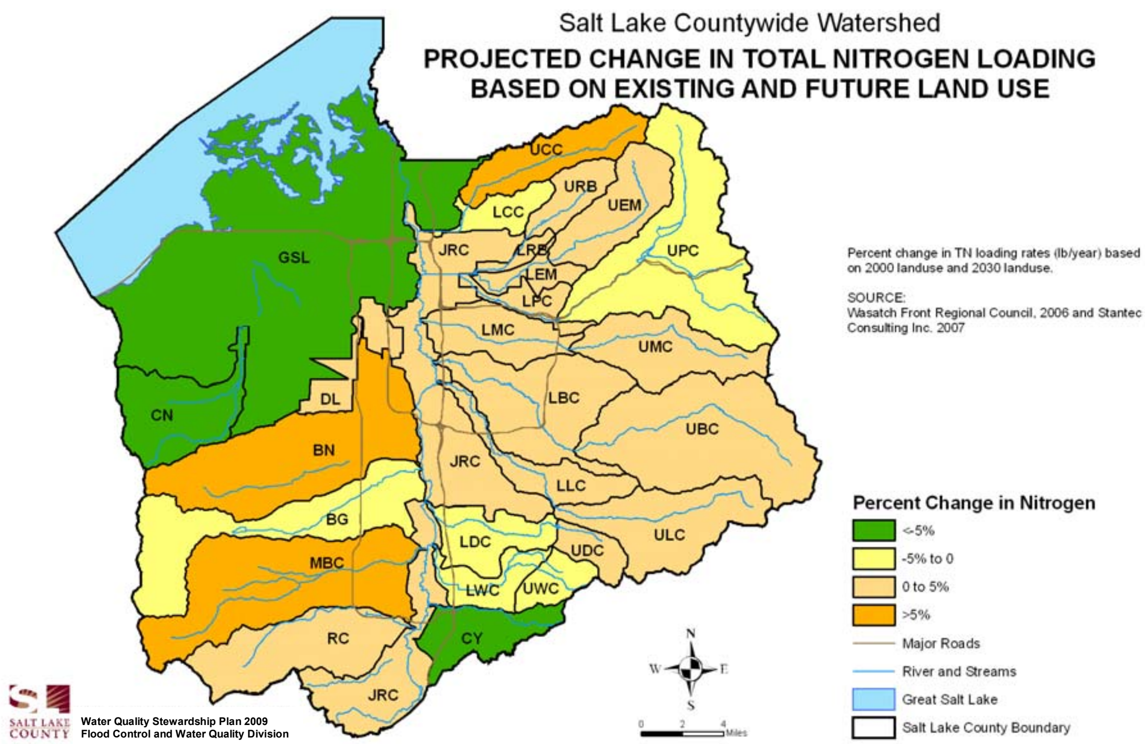


Figure 3.13.7 Projected Change in Total Nitrogen Loading

Table 3.13.7 Projected Change in Pollutant Loading Rates

Sub-watershed Code	Change in Pollutant Loading Rates (lbs/year)		
	TP	TN	TSS
BN	19.70	6.33	7.79
UBC	0.04	0.02	0.01
LBC	-2.54	2.30	-4.30
BG	10.20	-3.01	1.49
UCC	134.36	22.30	41.96
LCC	-3.40	-5.31	0.36
CN	41.31	-5.57	9.385
CY	-13.28	-6.10	-8.42
DL	-8.93	2.01	-7.90
UDC	21.33	4.10	4.16
LDC	-4.73	-1.29	-5.42
UEM	0.39	0.10	0.21
LEM	2.38	4.92	3.13
GSL	15.36	-5.58	6.76
JR	-8.12	0.13	-6.72
ULC	0.58	0.43	-0.29
LLC	-2.03	2.76	-4.77
MBC	21.53	6.51	7.46
UMC	0.55	0.15	0.10
LMC	-7.29	2.66	-4.51
UPC	-2.26	-0.51	-0.88
LPC	-0.74	3.973	-0.63
URB	7.55	1.56	1.88
LRB	-28.76	4.90	-23.59
RC	-0.21	1.17	1.81
UWC	-0.76	-0.17	1.38
LWC	-6.87	-1.597	-6.53

criteria for discharge effluent quality limitations. Required monitoring may be analytical or visual. Currently, stormwater permits do not have discharge effluent criteria limitations, but rather a requirement to implement best management practices (BMPs) designed to reduce stormwater pollutants to the Maximum Extent Practicable (MEP). It is important to note that most stormwater is not treated prior to discharge. Large Municipal Separate Storm Sewer Systems (MS4s) and some industrial stormwater permits require analytical monitoring.

Point source discharges into the Salt Lake Countywide Watershed currently operating under valid UPDES permits are identified in Figures 3.13.8 and 3.13.9. Stormwater permits issued for construction activities are not included herein, as these discharges are temporary in nature.

A list of UPDES permits in the Salt Lake County-wide Watershed is provided in Appendix B. Figure 3.13.8 includes UPDES permitted outfalls with the exception of Industrial Stormwater Discharge Permits. The number of Industrial Stormwater Discharge Permits by sub-watershed is shown in Figure 3.13.9. An MS4 stormwater discharge permit includes all stormwater outfalls under that jurisdiction; for example, there are approximately 400 stormwater outfalls currently permitted under the Jordan Valley Municipalities Municipal Stormwater Permit (UTS000001).

There are currently 31 UPDES discharge permits in the County, not including stormwater. These include the following DWQ categories: Publicly Owned Treatment Works (5), Standard Permits (12), General Drinking Water Plants (8), Groundwater Contaminated with Petro (1), and Biosolids Permits (5).

Information regarding pollutant levels discharged at these locations was not evaluated, and may be a consideration in future updates. As noted in Figure 3.13.9, the greatest number of industrial stormwater outfalls discharge in the Great Salt Lake Sub-Watershed (143), and the Jordan River Corridor Sub-Watershed (70).

Salt Lake County has extensive information regarding event mean concentrations and annual pollutant loading rates from stormwater discharges. According to the Stormwater Quality Data Technical Report (Salt Lake County, 2006) the

Dry Creek sedimentation, Lower Dry Creek Sub-Watershed

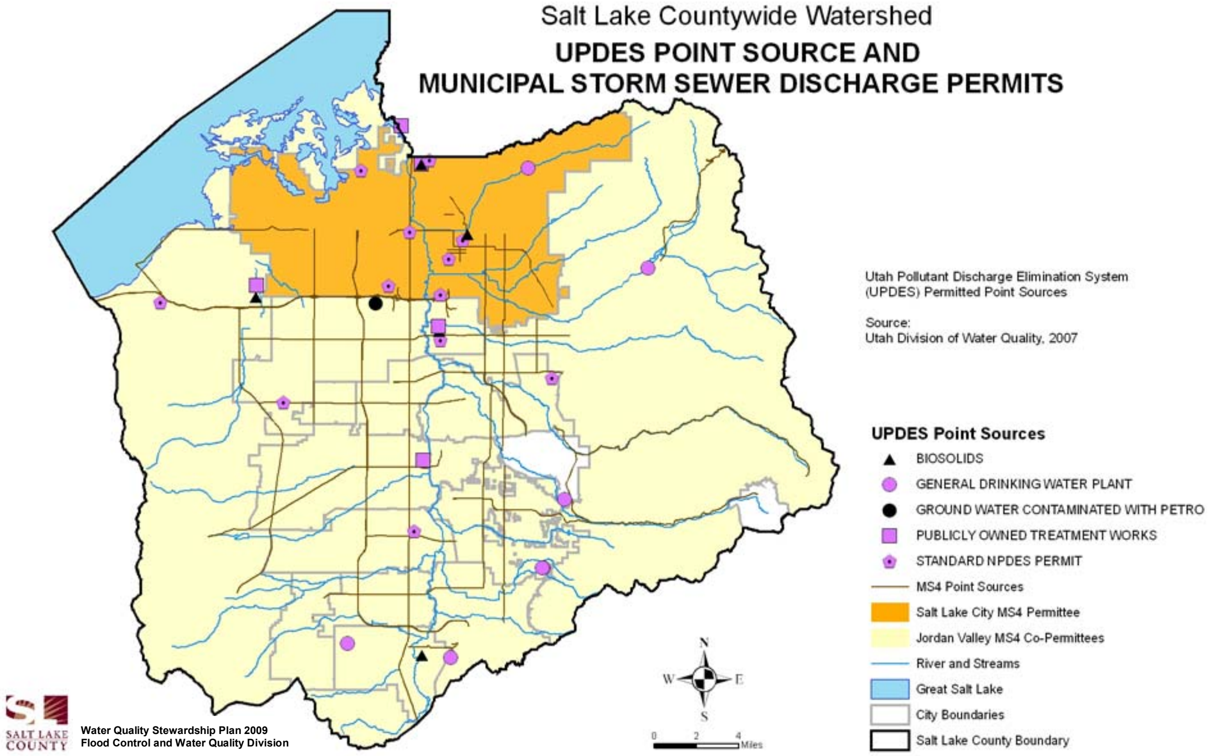


Figure 3.13.8 UPDES Point Source and Municipal Storm Sewer Discharge Permitees

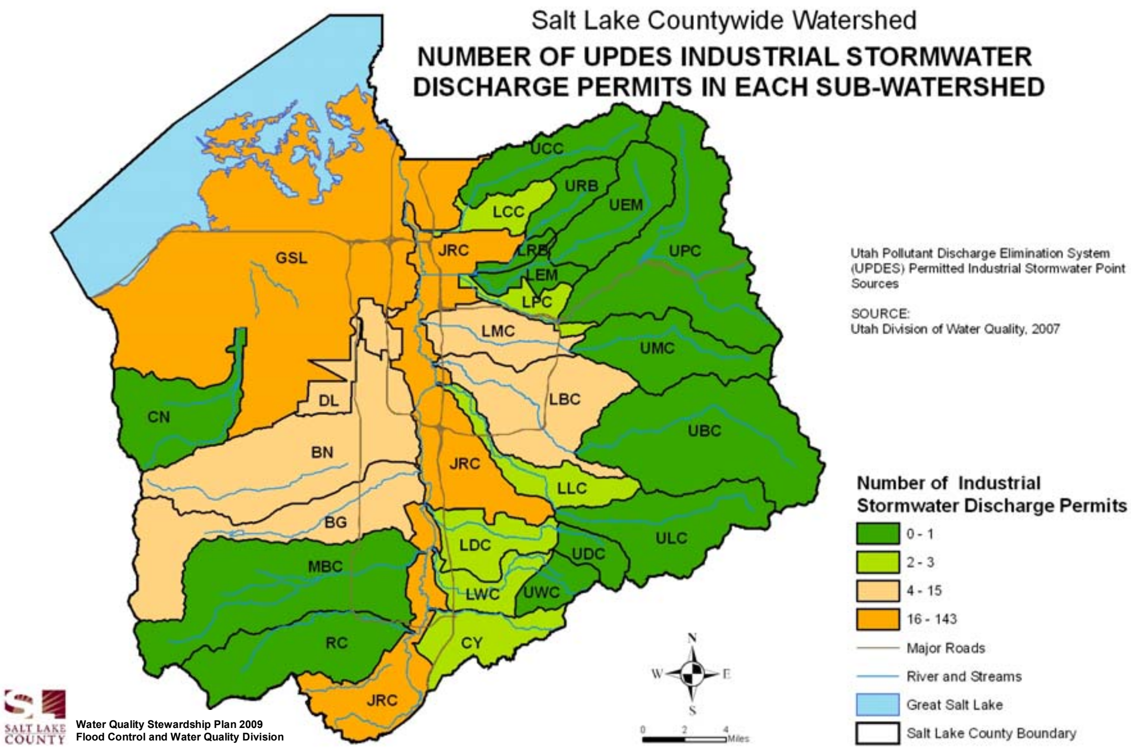


Figure 3.13.9 Number of UPDES Industrial Stormwater Discharge Permits

industrial land use contribution of pollutants concentration is lower than the other contributing land uses. Furthermore, it is important to note that through the UPDES permitting system and the TMDL process, point source discharges are effectively regulated and monitored.

3.13.6 Water Quality—Nonpoint Source Pollutants

Of the primary nonpoint pollutant sources identified in the State Nonpoint Source Plan, several have been identified in the Salt Lake Countywide Watershed (DEQ, 2000). These include agriculture (animal concentrations and irrigation water return flow), urban runoff (Christensen et al., 1982), hydrologic modification (Jensen, 1995), mining (DWQ, 2005), construction activities, on-site wastewater disposal (Jensen et al., 2003), and atmospheric deposition (Christensen et al., 1982).

Several creeks and streams in the Watershed have been impacted by one or more non-point sources, some to the extent that the protected beneficial uses of the waterbody have been impaired (Section 3.13.2). For example, the Jordan River has been significantly impacted by hydrologic modifications, irrigation return flow from canals and Utah Lake, and animal concentrations (agricultural or non-domestic waterfowl) (Robinson, 1995). Additionally, there are significant trash concerns in the Jordan River. However, not all nonpoint sources and pollutant loads have been quantified in the Watershed, making regulatory solutions from implementing TMDL's difficult or infeasible. The TMDL process described by the Utah DWQ (Utah DEQ, 2000) is set forth to address quantification of pollutant loads and subsequent regulatory issues.

3.14 CONCLUSION

In order to identify implementation activities that will address watershed and water quality concerns detailed in this chapter, water quality, habitat, hydrological and social/recreation characteristics are analyzed by sub-watershed in Chapter 5.0. With this more detailed analysis of the data, specific implementation recommendations are made in Chapter 5.0 for each sub-watershed.