3.0 BASELINE ASSESSMENT RESULTS

Watershed Conditions

Size and Land Use

Red Butte Creek is located between City Creek to the north and Emigration Creek to the south (Figure 3.1). The upper subwatershed, located above the University of Utah, drains 5,403 acres of mountainous land primarily owned and managed by the U.S. Forest Service (USFS). Nearly 80% of the stream through the upper subwatershed is adjacent to public land. Public access is limited, though, as much of the area is managed as a Research Natural Area with a focus on study and research of the relatively pristine natural forest and riparian habitats (SLCO 2009). The estimated impervious cover of the upper subwatershed is 9.1%.

From its headwaters at an elevation of about 8,200 feet, the stream flows through a relatively wide canyon for just over 4 miles before it enters Red Butte Reservoir. This approximately

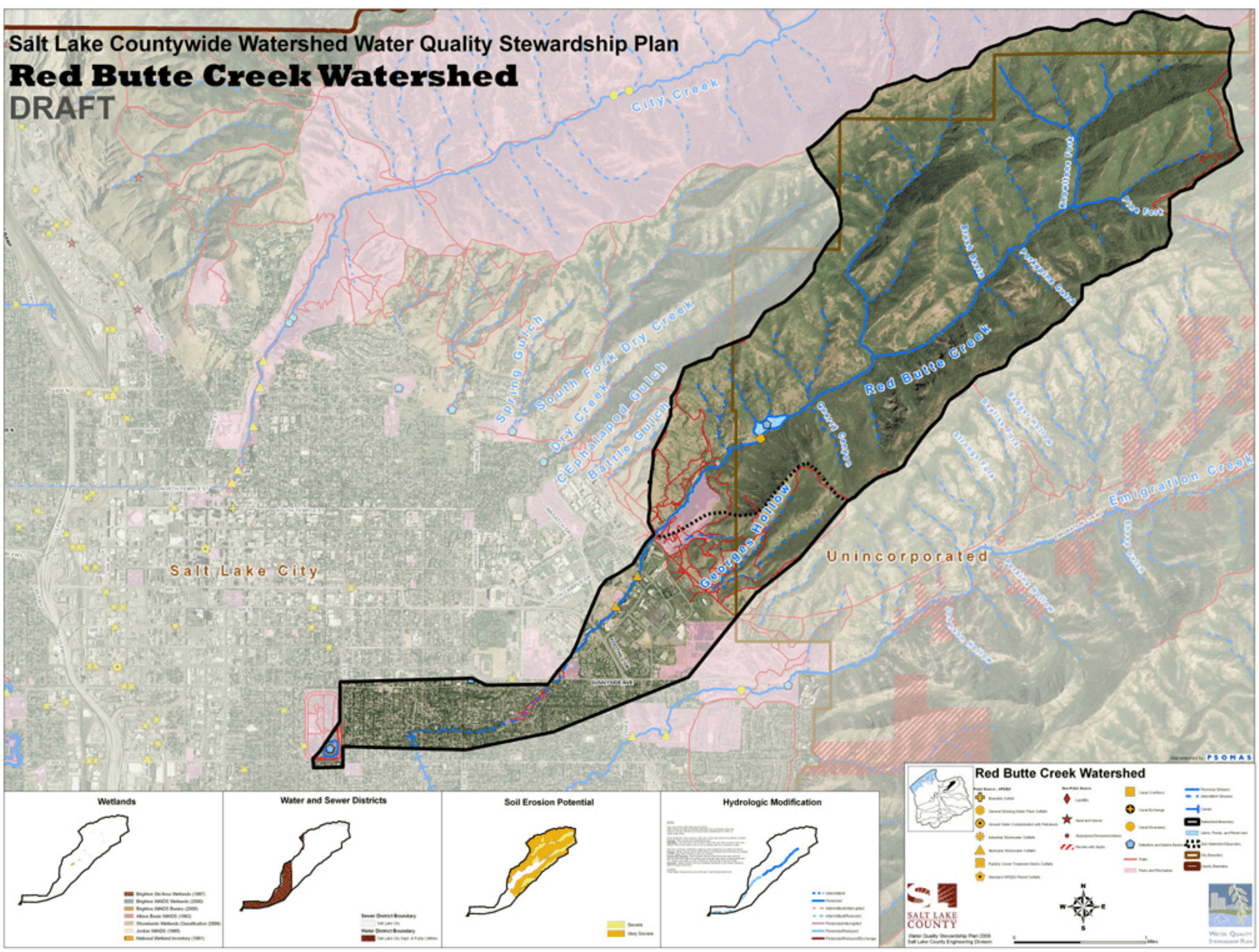


Figure 3.1. Red Butte Creek watershed. (Map from SLCO 2009).

400-acre-foot reservoir was originally constructed in 1930 by the U.S. Army, and in 2003–2004 ownership and management of the dam and reservoir transferred to the Central Utah Water Conservancy District (Billman et al. 2006). The reservoir is currently managed to maintain a generally constant reservoir elevation; during the early springtime, however, the reservoir is typically lowered to provide some flood storage capacity during the snowmelt runoff period (J. Crofts 2009, pers. comm.). During the nonrunoff portion of the year, reservoir inflows and outflows are typically similar. Reservoir management focuses on maintaining habitat quality for the refuge population of endangered June sucker (*Chasmistes liorus*) that currently inhabit the reservoir (Billman et al. 2006).

The lower Red Butte Creek subwatershed is much smaller, draining 1,652 acres from the mouth of Red Butte Canyon downstream 2.7 miles to a point just west of 1100 East (SLCO 2009). The creek flows through the University of Utah campus and research park, the Veteran's Affairs (VA) Medical Center complex, Sunnyside Park, and then though primarily residential neighborhoods. The open-channel portion of Red Butte Creek terminates in the 1300 South conduit, which conveys the creek to the Jordan River via a 3.4-mile-long pipe. Red Butte Creek has the most highly urbanized lower subwatershed of the four streams included in the RCS, with impervious cover estimated at 31.9%.

Hydrology

Because of natural alluvial deposition patterns, Wasatch mountain streams—including Red Butte Creek—naturally lose some surfaceflow to groundwater where the canyons transition to the valley. Within most of the RCS study area, Red Butte Creek flows through areas mapped as primary and secondary groundwater recharge zones, and studies have estimated losses to groundwater to be around 0.2 cubic feet per second (cfs) in summer and fall and up to 2.3 cfs during spring (SLCO 2009). In its lower reaches below 1600 East, Red Butte Creek gains flow from various springs that discharge along the streambanks.

Urbanization and development throughout the watershed have altered surface water-groundwater patterns. As more of the watershed has been converted to impervious surfaces, a greater proportion of storm water runs off as surfaceflow rather than infiltrating into the ground, leaving less groundwater available to supply baseflow to the creek during the summer dry period (Figure 3.2). Red Butte Creek is classified as having

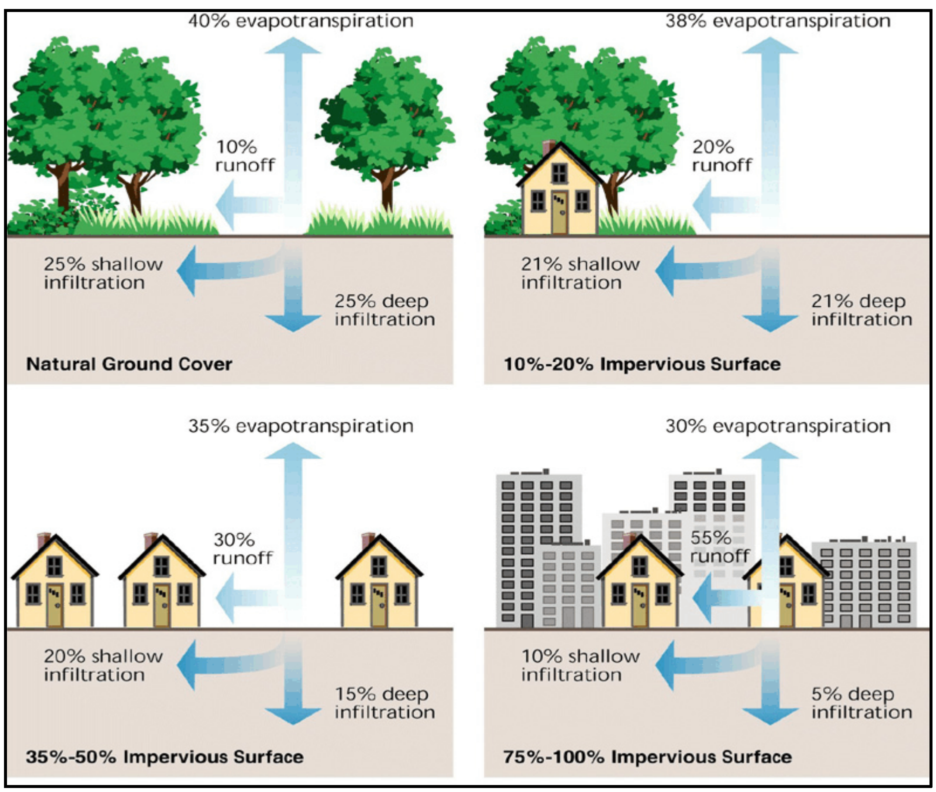


Figure 3.2. Relationship between impervious cover and surface runoff. Impervious cover in a watershed results in increased surface runoff. (Diagram and caption text from FISRWG 1998).

perennial flow upstream of Red Butte Reservoir and is considered to have "perennial-reduced" flow below that point, indicating that flows are artificially reduced by stream diversions (SLCO 2009). At the RCS public workshops, residents of the lower portions of the creek indicated concerns over summertime reduced flows apparently associated with diversion operations.

Within the study area, recorded points of diversion include a structure near the middle of reach LRB_R05C (a 3.8-cfs water right) and several small springs on residential properties between 1100 East and 1500 East (UDWRT 2010). During baseline assessment field work, diversion headgates were also observed at the downstream end of reach LRB_R05B.

Red Butte Creek's hydrology is characterized by a distinct springtime peak typical of snowmelt-driven systems. Based on analysis of flow data recorded at the County gage near 1600 East from 1984–2005, average monthly flow is highest in May (Figure 3.3), and peak daily flow occurs on April 30 on average (SLCO 2009). Average annual high flow is 22 cfs while typical base flows are approximately 2 cfs. Field observations during storm events suggest that flows in the lower reaches of the creek are quite "flashy" with rapid, brief rises in flow during storms. This is a common hydrologic pattern in urbanized systems (Figure 3.4). An example of this storm flow response can be seen in Figure 3.5, which plots the flows recorded at the USGS gage above Red Butte Reservoir and at the County gage near 1600 East during a rain event in April 2009. Analysis of flow records at the two gages provides further evidence of the flashy hydrology at the urbanized lower gage site,

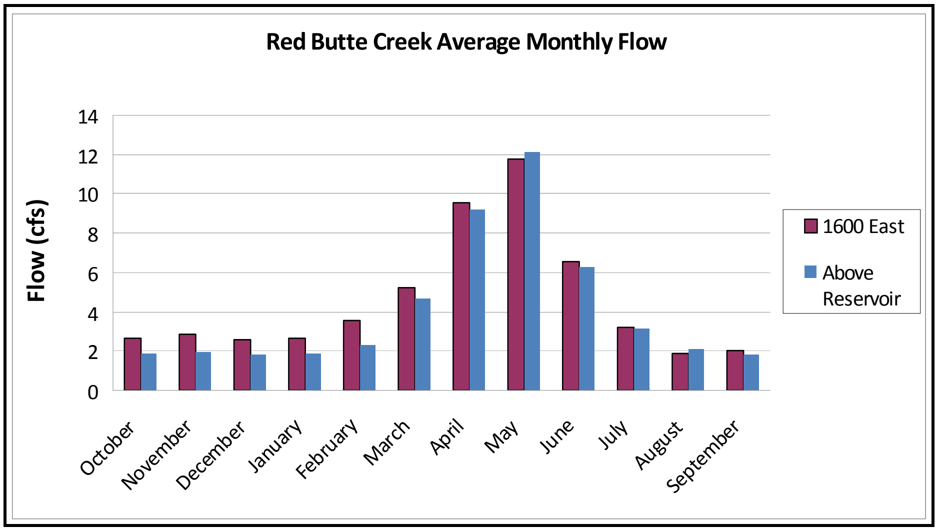


Figure 3.3. Monthly flows at Salt Lake County's gage at 1600 East and the U.S. Geological Survey gage above Red Butte Reservoir.

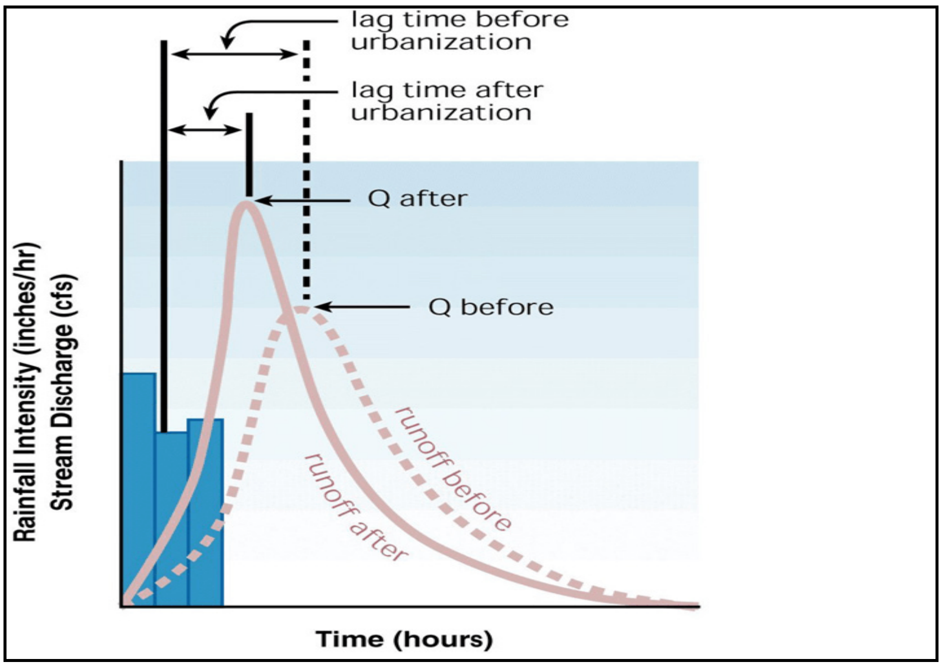


Figure 3.4. A comparison of hydrographs before and after urbanization. The discharge curve is higher and steeper for urban streams than for natural streams. (Diagram and caption text from FISRWG 1998).

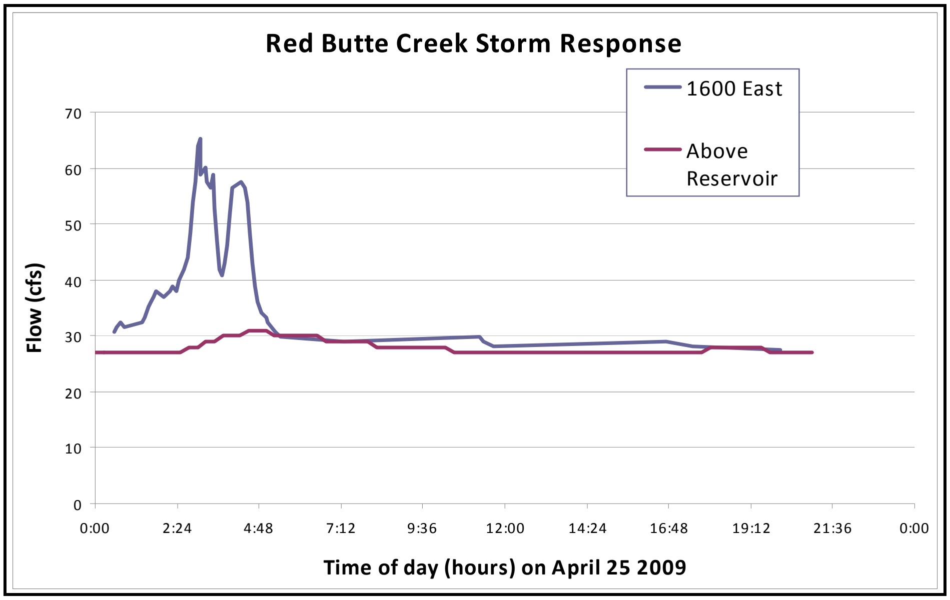


Figure 3.5. Streamflow response to April 25 storm event (0.5 inch of rain between midnight and 3:30 AM) at the gages above the reservoir and 1600 East. At the 1600 East gage, which drains the urbanized lower subwatershed (31.9% impervious cover), flows increased by 30 cubic feet per second (cfs) in response to the rain event while flows in the upper subwatershed (9.1% impervious cover) only increased by 4 cfs.

which has rise and fall rates about five times greater than the undeveloped upper gage site.

As discussed above, Red Butte Reservoir is managed to provide some degree of flood storage (J. Crofts 2009, pers. comm.). However, analysis of flow data indicates that the magnitude and timing of annual peak flows is similar above and below the reservoir and the dam influence on flood hydrology is relatively minor. The potentially more significant dam effect is on downstream sediment supply, as all bedload is trapped in the reservoir and only a portion of the suspended load is conveyed downstream.

Water Quality

Designated beneficial uses of upper Red Butte Creek above the reservoir are 1C (high-quality drinking water), 2B (secondary contact recreation, and 3A (cold-water fishery). Below the reservoir the creek is designated with the default classifications of 2B and 3D (waterfowl/shorebird protection). Red Butte Creek is currently assessed as meeting its designated beneficial use classifications (DWQ 2006). As part of its standard water quality monitoring program, the Utah Division of Water Quality (DWQ) collects water quality data at three monitoring stations in upper Red Butte Creek above the reservoir (STORET numbers 4992100, 4992110, and 4992120) and at one station below the reservoir at the USFS boundary (STORET number 4992090; EPA 2009). During spring and summer 2009, additional E. coli sampling was also conducted by the DWQ at the station at the USFS boundary as part of an on-going bacteriological sampling effort. The County also collects macroinvertebrate (aquatic insect) data on Red Butte Creek as part of its Stream Function Index data collection program (SLCO 2009).

No established DWQ water quality monitoring stations are present on lower Red Butte Creek within the RCS study area. However, data have been collected for several years at a station on the 1300 South conduit (STORET 4992070). Water in the conduit originates from Emigration, Parleys, and Red Butte Creeks, so the data collected at this monitoring station provide an indication of water quality conditions and storm water effects within the lower, urbanized portions of these creeks. Potential nonpoint source pollution contributors within lower Red Butte Creek include urban runoff, active construction sites, and managed parks and campus areas.

Geology and Soils

The surficial geology of the upper Red Butte Creek subwatershed is composed of various members of the Triassic Ankareh formation, as well as Jurassic/Triassic Nugget Sandstone (Bryant 1990). Approximately 50–86.2% of the soils in the upper subwatershed have severe to very severe erosion potential. Once it exits the canyon, Red Butte Creek flows through alluvial and debris fan deposits and a series of Pleistocene Lake Bonneville deposits. These deposits range in size from finer-grained silt and clay deposits to coarser sand and gravel deposits. In the lower subwatershed, 20–35% of the soils have severe to very severe erosion potential (SLCO 2009).

After Lake Bonneville receded approximately 16,000 years ago, it left a series of old shoreline deposits that now form prominent "benches" along the edges of Salt Lake Valley. To reach its modern base level at the Jordan River, Red Butte Creek had to carve through these deposits. In part because of this natural geologic history, stream gradient is relatively steep and the creek is entrenched between tall slopes that extend up to the Bonneville bench levels. Various human-caused alterations to the creek—including channel straightening, installation of road crossing culverts, fill placement, and bank hardening—have further contributed to the steep grade and entrenched shape of the channel.

Fish, Birds, and Wildlife

Quantitative data on fish and wildlife populations within the urban portion of Red Butte Creek are limited. A managed population of native Bonneville cutthroat trout (*Oncorhynchus clarki utah*) exists in the creek above the Red Butte Reservoir (Billman et al. 2006). Lower Red Butte Creek is not reported in agency publications as supporting a fishery (SLCO 2009) but RCS workshop attendees indicated that they have seen fish in the creek within the RCS study area, perhaps from private landowners stocking small numbers of trout for fishing.

Deer were observed in the Sunnyside Park area during RCS field assessment work. During the Audubon Society's 2005 Christmas bird count, a total of 30 different bird species were observed within the University of Utah survey area, which includes portions of the Red Butte Creek riparian corridor (Carr 2009). At the RCS public workshops, residents reported regularly seeing nuisance wildlife species including racoons and skunks. Reach LRB_R07, which includes the Miller Bird Refuge and Bonneville Glen park areas, is a recommended site for recreational birding within the County.

Historical Conditions and Current Trends

Red Butte Creek History

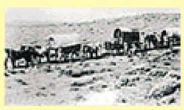
Red Butte Creek played an important role in the initial settlement and development of Salt Lake City by the Mormon pioneers who entered the valley in 1847. The creek was tapped for water supply for homes and orchards built in the early 1850s. The pioneers also quarried sandstone and some limestone from the canyon, building a quarry access road in 1848 (Ehleringer et al. 1992). Some minor logging and grazing activity also took place during the initial settlement period.

When Fort Douglas was established by the U.S. Army in 1862, conflicts arose with Salt Lake City over the use and quality of the Red Butte Creek water supply (Figure 3.6). The upper Red Butte Creek watershed has been under Federal ownership and protection since about 1900, and today functions as a USFS Research Natural Area (Red Butte Canyon RNA 2009). Because of this history of protection, the upper watershed remains in a relatively pristine condition.

Early descriptions of the stream and its riparian corridor are limited. One account describes abundant green grass growing along the creek (LDS CHO 1990). Publications suggest the stream historically supported a Bonneville cutthroat trout fishery that provided a food supply to the pioneers (Billman et al. 2006). One pioneer account describes a broad, grassy marsh area at the confluence of Parleys, Emigration, and Red Butte creeks

1847

Portions of Red Butte Canyon were logged and sandstone was mined by pioneers that had just arrived in Salt Lake Valley. Bonneville cutthroat trout likely inhabited Red Butte Creek when the Salt Lake Valley was settled and settlers used the fish for food.[1]



1853

"Red Butte Creek was an early water supply for the Mormon Pioneers. On July 9, 1853, the City Council passed an ordinance creating the office of Water Master. The duties consisted of overseeing the construction and repair of gates, locks and sluices as necessary to admit into the City the water from City Creek, Red Butte and Emigration Canyons and to divide the water throughout the City to best serve the public interest for irrigation, domestic and other purposes."

-Red Butte Canyon Research Natural Area Website[2]

1862-90

On-going court battles between Salt Lake City and the U.S. Army over water use and water quality of Red Butte Creek. Ultimately, the majority of water rights went to the U.S. Army and Fort Douglas.[2]

1863

"On October 26, 1862, Fort Douglas was established by a garrison of volunteer troops under the command of Colonel Conner. These troops used the waters of Red Butte Creek for domestic and irrigation purposes. The Army constructed ditches and a reservoir to supply its domestic needs and irrigation of gardens and grounds. The diversions of water by the garrison affected 3,000 Salt Lake City residents located in the First and Fourth Municipal Wards who used Red Butte Creek as their water supply.

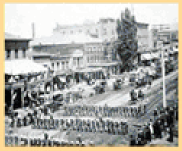
1930-85

Member of the University of Utah botany department and co-founder of The Nature Conservancy, Dr. Walter P. Cottam, began conducting botanical research on campus land. The state legislature recognized Cottam's work and designated the campus landscape as a Utah State arboretum. The university later dedicated 100 acres at the mouth of Red Butte Canyon as a regional botanical garden, and the community raised funds to change the name from State Arboretum to Red Butte Garden and Arboretum.

1983-87

Red Butte Creek and Reservoir were treated with a fish toxicant prior to stocking Bonneville cutthroat trout. Major flooding also occurred during this time, destroying beaver dams in Red Butte Canyon and affecting creek-side city residents.[1]

Figure 3.6. Red Butte Creek historical timeline.



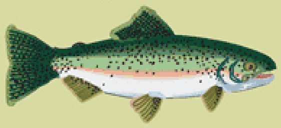
The following spring a Grand Jury presented to the United States District Court for the Third Judicial District of Utah Territory a statement of fact that the watercourse or stream called Red Butte was conducted into the City for the use of its inhabitants and 3,000 citizens depend entirely upon this water for irrigation, culinary, and drinking purposes.

That on or about October 20, 1862 the California Volunteers established a military encampment and built stables, yards, corrals and diverted the water from its channel through the yards built for their animals and have built privies on or near the stream and thus polluted the water so badly that the 3,000 citizens downstream could not use it for any purpose including irrigation since it was filthy. (The first and fourth municipal wards included the area between Third and Thirteenth East, and South Temple to Ninth South Street)"
- Red Butte Canyon Research Natural Area Website

2

1930

Red Butte Dam is erected through a joint effort by the Army and Salt Lake City.[1]

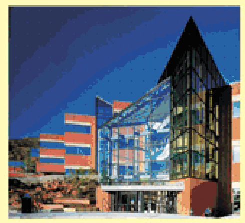


1947

The military created a recreational fishery for its personnel on Red Butte Reservoir and the U.S. Fish and Wildlife Service began stocking the reservoir and stream.[1]

1968-70

The several thousand-acre Red Butte watershed was transferred to the Forest Service, and the University of Utah was granted the area now occupied by Research Park.[3]



FOOTNOTES

1 Billman et al. 2006
2 http://redbuttecanyon.net/protectedwatershed.html 2009
3 http://web.utah.edu/facilities/fd/history/history.html 2009
4 http://www.redbuttegarden.org/about-us/mission%2526history 2009
5 CUWCD et al. 2005

1991-93

Fort Douglas closes and lands are transferred to the Utah National Guard, U.S. Army reserve units, and the University of Utah.[4]

1992

June sucker, an endangered fish native to Utah Lake, stocked into Red Butte Reservoir.[5]

1998

U.S. Army abandons active management of Red Butte Dam.[2]

2004

Ownership and management of the reservoir transferred to the Central Utah Water Conservancy District.[5]

2005

Reservoir drained for dam improvement work and to control illegally introduced exotic crayfish.[2]

Historical activities that have altered riparian corridor conditions:

- mining and quarrying for sandstone
- beaver trapping and removal
- channel clearing and debris removal
- flow diversion for irrigation and drinking water
- development and piping of springs
- road and stream crossing construction
- residential and commercial development
- introduction of invasive, nonnative plants
- piping of the creek in underground conduits
- channel relocation/ straightening
- bank armoring
- placement of fill within floodplain areas
- construction and management of Red Butte Dam and Reservoir
- development and operation of Fort Douglas

that made wagon travel challenging (Dixon 1997). Modern descriptions of the protected upper reaches of Red Butte Creek, above the RCS study area, suggest that the presence or absence of beaver dams plays a highly significant role in the condition of the channel and its riparian area. Prior to the 1983 spring flood, numerous beaver dams were present in the upper portions of Red Butte Creek. The frequent "checks" on flow velocity provided by the beaver dams created pool and run habitats surrounded by diverse, marshy riparian vegetation. These habitats were greatly reduced when the beaver dams were washed out by the 1983 flood (Ehleringer et al. 1992). Considerable slope slumping, streambed erosion, and gully formation also occurred during the flood.

Alterations to the Riparian Corridor

Over the last 160 years, the various activities associated with development and population growth in Salt Lake Valley have resulted in significant alterations to the stream channel and riparian conditions of lower Red Butte Creek. Among other factors, systematic programs to remove beaver populations have likely contributed to the currently reduced vegetation density relative to historical conditions. When beaver were more common, their dams increased inundated streamside habitat area, elevated the water table, reduced flood velocities and erosion, and trapped sediment and nutrients (Gardner et al. 1999).

As beaver populations were reduced, the "checks" on sediment and water created by beaver dams also decreased, resulting in greater flow velocities and streambed down-cutting (Wohl 2000). Beaver populations flourished in Red Butte Canyon (above the RCS study area) from 1928 until 1982, when they were removed by the U.S. Army over concerns about bacteriological contamination of the water supply to Fort Douglas. The absence of live beaver populations prior to, during, and immediately following the 1983 flood contributed to erosion damage caused by the flood. Beaver populations appear to be currently absent within the RCS study area.

Many of the direct alterations to lower Red Butte Creek have occurred in order to address flooding concerns and accommodate urban development and population growth. One of the most significant direct changes to the creek was the construction of the 1300 South conduit, which converted the western open-channel portions of Emigration, Red Butte, and Parleys Creeks to an underground pipe system. The exact date of conduit construction is not known but housing stock located over the conduit system dates to the late 1920s, suggesting that construction was complete prior to that time. No creek channel can be seen west of 1100 East in 1938 air photos of Salt Lake City (Bowman and Beisner 2008).

In general, the channel alignment of Red Butte Creek does not appear to have changed dramatically since 1938. Some relatively minor bend straightening is evident in portions of the channel within the areas that are now Bonneville Glen and Sunnyside Park (Figures 3.7 and 3.8). Another significant change since 1938 has been an increase in length and number of culvert pipes. Near 1500 East, approximately 300 feet of what used to be open stream channel (Bowman and Beisner 2008) is now piped under a parking lot (Figure 3.7). Similarly, just downstream from Foothill Drive, approximately 130 feet of what was once forested stream channel is now piped under a road crossing (Figure 3.8). The construction of culvert crossings and the piping of portions of Red Butte Creek facilitated urban growth but also reduced total channel length, resulting in greater channel slope and higher stream velocities. The culverts have also disrupted the connectivity of the riparian corridor by creating barriers to fish and wildlife migration.

In some residential areas along the creek, it appears that tree canopy density has increased

Figure 3.7. 1938 aerial photograph of Red Butte Creek from 900 South to 1500 East. Photograph is overlaid with 2006 channel alignment in red; gaps in line indicate underground culverts.

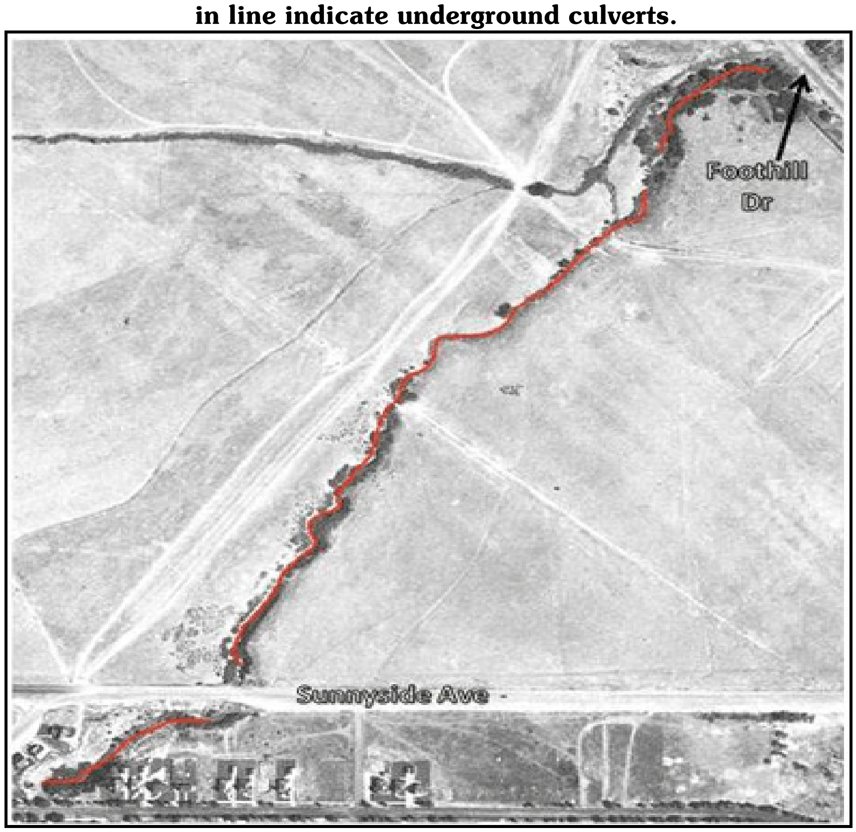


Figure 3.8. 1938 aerial photograph of Red Butte Creek from Foothill Drive to Sunnyside Avenue. Photograph is overlaid with 2006 channel alignment in red; gaps in line indicate underground culverts.

since 1938. This is most likely the result of landscaping and tree planting as dense residential neighborhoods were built along the creek. Much of the residential development within the RCS study area is estimated to have occurred between 1915 and 1940. This development primarily affected areas downstream from Sunnyside Avenue (Figure 2.1). A second phase of urbanization within the areas upstream of Sunnyside Avenue began around 1970.

This second phase involved development of the VA Medical Center complex and University of Utah research park facilities. Building expansion work and new construction projects continue in these areas today.

Urban Channel Adjustments

Urbanized streams have been found to undergo a sequence of typical channel adjustments in response to changes in hydrology and sediment supply (Wolman 1967, Riley 1998, and Colosimo and Wilcock 2007). Studies of urban channel adjustment generally identify two main stages of adjustment: an early depositional phase and a later, fully urbanized phase. The early phase occurs during initial development when active construction leads to increased fine sediment supply, increased bar deposits, and reduced channel size. The late/fully urbanized phase occurs after construction activities are essentially complete and the watershed has become stable with a high percentage of impervious surface area and runoff magnitudes and volumes have correspondingly increased. Channels in the "late urbanized" phase are typically enlarged relative to their original form due to an oversupply of water relative to sediment supply. These channels have few bar deposits and are commonly down-cut (incised) with reduced floodplain access (Figure 3.9). Many of the reaches of Red Butte Creek that we assessed exhibit characteristics of the "late urbanized" phase, such as evidence of down-cutting and low bank erosion/root scour.

Other influences such as localized sediment inputs from eroding storm drain outfalls or sediment deposition near culvert inlets modify conditions from this generalized "late urbanized" channel condition. Existing channel conditions within the Red Butte Creek corridor reflect a complex response to a variety of historical and on-going alterations throughout the makes it difficult to distinguish whether channel lowering and

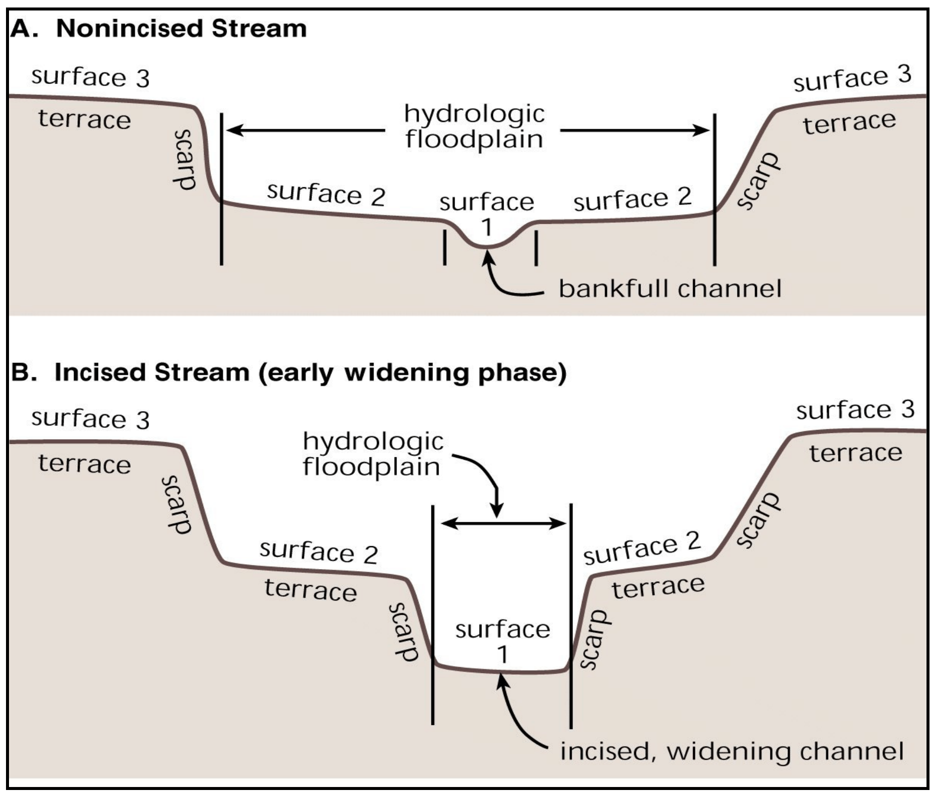


Figure 3.9. Illustration of streambed lowering (incision) process common on urbanized streams. Following initial incision (B), the channel may continue to incise and widen until a new equilibrium channel/floodplain geometry is reached, posing a potential risk to urban development on terrace surfaces adjacent to the channel (Diagram from FISRWG 1998).

watershed. This complexity bank erosion observed in a specific location are due to a corridor-scale streambed lowering trend, a localized culvert or bank treatment effect, or combination of several factors.

Recent and Anticipated Future Trends

Anticipated future land use changes are minimal within the upper Red Butte Creek subwatershed. Within the lower subwatershed, additional development is primarily anticipated to occur within the areas occupied by the University of Utah's research park and the VA complex. The impervious cover of the lower subwatershed is expected to increase significantly by 2030, to a total impervious cover value of 43.8% (SLCO 2009).

Climate change is another factor that can be anticipated to affect the Red Butte Creek riparian corridor. Climate projections for the southwestern region of the United States show increased temperatures, reduced mountain snowpack, a 10–20% decrease in annual runoff volume, reduced springtime precipitation amounts, and anticipated water supply shortages (Karl et al. 2009). The risk of drought, as well as the risk of flooding, is also expected to increase. The changes in temperature will likely result in a shift in vegetation communities, and altered precipitation patterns will influence stream hydrology and channel conditions. The timing of snowmelt runoff is expected to occur earlier in the spring, with a reduction in summertime base flows anticipated (Karl et al. 2009).

Stream and Vegetation Conditions

Stream Channel Characteristics

Salt Lake County has classified the stream reaches within the lower Red Butte Creek subwatershed as entrenched to moderately entrenched, meaning the channel is vertically confined. Over 60% of the channel in the lower subwatershed received a fair to poor stream stability rating during County stream studies; upper subwatershed reaches URB_R09 and URB_R10 both received fair stability ratings (K. Collins 2009, pers. comm.). During field assessments in 2008, the County classified lower Red Butte Creek as Rosgen (1996) stream types A3 and B3 between lower Red Butte Garden and 1500 East (reaches LRB_R01 through LRB_R07), and types A4 and B4 below 1500 East. Stream reaches in the upper subwatershed were assessed in 2007 and the assigned stream type for reaches URB_R09 and URB_R10 was B3 (K. Collins 2009, pers. comm.). County bankfull width estimates for the stream reaches in lower Red Butte Creek ranged from 8 to 20 feet, with an average of 13 feet. Estimates for reaches URB_R09 and URB_R10 were 14 and 15 feet, respectively (K. Collins 2009, pers. comm.).

Results of RCS field surveys and GIS analyses further illustrate the fact that the Red Butte Creek channel is commonly entrenched and typically inset between tall, steep slopes (Figure 3.10). Because of this characteristic, residents along the creek corridor who attended the RCS public workshops often refer to the channel as a "gully" or "ravine." The steep side slopes also make access to the creek challenging in many areas. However, the extent of vertical confinement varies, and in some locations the channel shape is wider (Figure 3.10). These wider areas are important because they allow water to spread out horizontally during flood events, dissipating velocity and reducing erosion potential.

Surveyed channel width values are quite variable, ranging from about 4–11 feet at low flow, with an average value of 8 feet (Table 3.1). High flow surveys were conducted at a streamflow of 19 cfs, which is close to the average annual high flow value of 22 cfs. Width at this high flow value varies from about 6 to 16 feet, with an average of 10 feet. In some reaches, particularly the downstream reaches in older residential neighborhoods, channel width is directly affected by installed bank hardening measures such as grouted rock walls. Channel slope, as determined for each stream reach from digital elevation data,

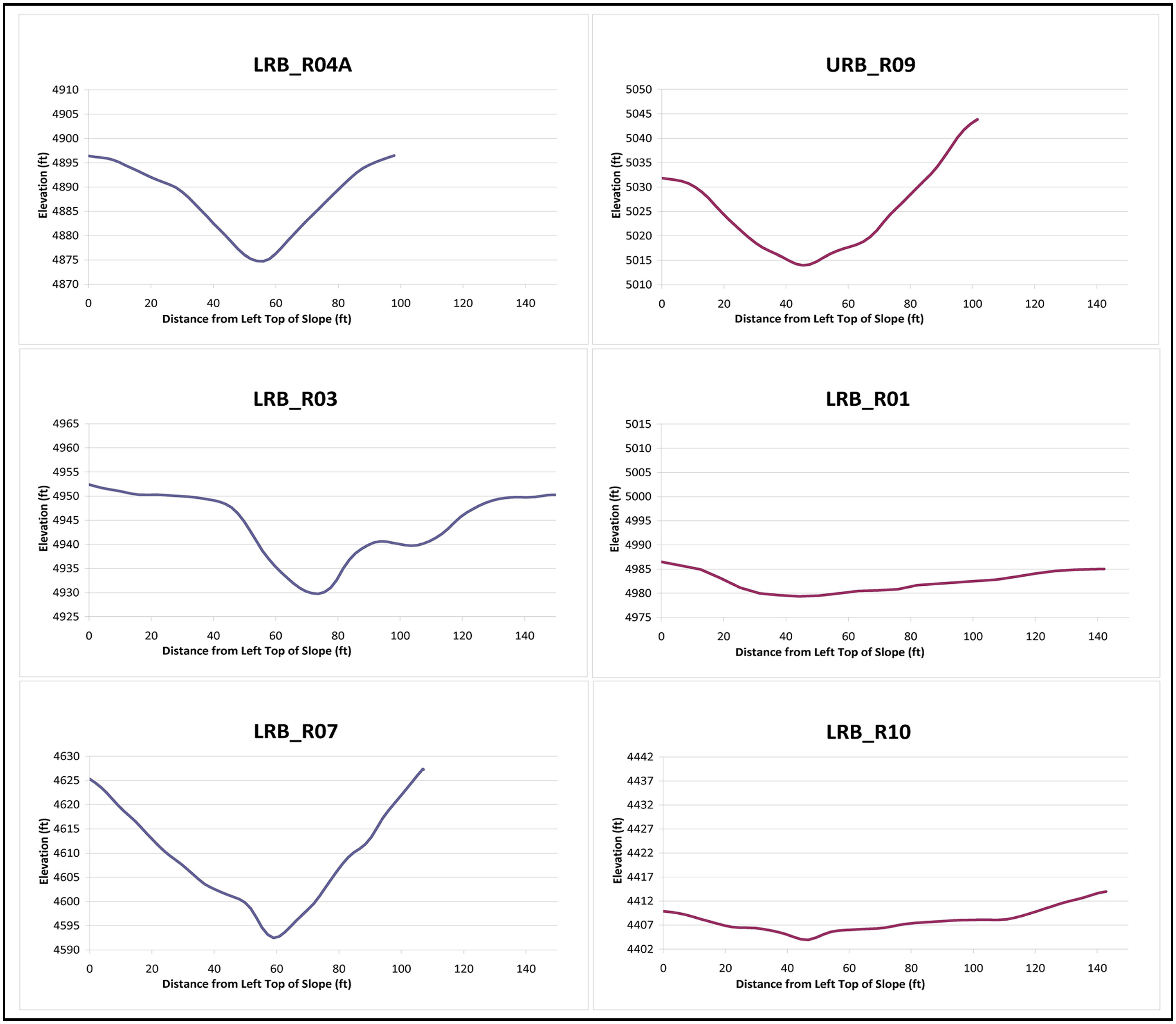


Figure 3.10. Cross-section plots extrapolated from digital elevation data. Plots on left (in blue) exhibit a high degree of vertical confinement between tall, steep side slopes. Plots on right (in red) exhibit less vertical confinement.

varies from 3.1–6.7% within the RCS study area with an average value of 4.6% (Figure 3.11, Table 3.1).

Red Butte Creek does not show any consistent spatial trends in gradient through the study area because the valley slope remains steep throughout the study area, which traverses Lake Bonneville bench deposits. The valley becomes significantly flatter west of 1100 East and, historically, Red Butte Creek would have shifted to a flatter, less confined, more sinuous channel type in this area. However, this portion of the creek is now piped underground in the 1300 South conduit.

Median (D50) streambed particle sizes at the measured cross

Table 3.1 Summary of streambed material, channel geometry, and slope data.

REACH NUMBER	MEASURED VALUES AT RIFFLE CROSS SECTION							REACH DATA	
	STREAMBED MATERIAL SIZE DATA				CHANNEL GEOMETRY				
	D16 (mm) [a]	D50 (mm) [a]	D84 (mm) [a]	Percent Embedded	Low Flow Wetted Width (ft) [b]	Wetted Width (ft) [b] at 16 cfs [c]	Local Slope (ft/ft) [d]	Reach Slope (ft/ft) [d]	Reach Length (ft) [b]
URB_R09	12	75	164	25	10.0	10.5	0.036	0.051	2297
URB_R10	-	-	-	-	-	-	-	0.067	827
LRB_R01	6	51	111	9	6.7	16.2	0.023	0.043	281
LRB_R02	<2	12	27	5	7.0	11.3	0.009	0.053	451
LRB_R03	5	30	181	32	10.8	11.1	0.094	0.062	1041
LRB_R04A	<2	23	86	15	4.3	6.0	0.032	0.053	961
LRB_R04B	9	45	95	11	6.3	8.9	0.018	0.040	595
LRB_R04C	3	27	79	16	7.9	8.6	0.048	0.032	1294
LRB_R05A	9	42	104	6	9.9	10.4	0.054	0.055	433
LRB_R05B	12	41	104	4	8.4	10.2	0.042	0.031	1081
LRB_R05C	9	42	134	16	5.8	7.6	0.028	0.037	887
LRB_R06	-	-	-	-	-	-	-	0.046	492
LRB_R07	12	37	111	10	9.4	10.0	0.021	0.036	2084
LRB_R08	-	-	-	-	-	-	-	0.044	1059
LRB_R09	-	-	-	-	-	-	-	0.053	633
LRB_R10	10	32	77	3	5.8	7.4 [e]	0.057	0.041	1449
LRB_R11	-	-	-	-	-	-	-	0.043	301

[a] The 16th, 50th, and 84th percentile values of the particle size distribution, in millimeters.
[b] Feet.
[c] Cubic feet per second.
[d] Feet per feet.
[e] Wetted width at 10.5 cubic feet per second.

sections range from 12–75 millimeters, indicating that medium- and large-sized gravel are the dominant substrate sizes in riffle areas of Red Butte Creek (Table 3.1). At most of the cross-section riffles, fine gravel comprises the D16 particle size and cobble-sized material comprises the D84 particle size (Table 3.1). Embeddedness values are highly variable. In flatter-gradient portions of the channel, such as run and pool areas, particle sizes are smaller with sand and silt often dominant. No consistent upstream-to-downstream trends are evident in the pebble count results; rather, bed material size and embeddedness appear to be largely a function of local factors such as sediment inputs from erosion areas and composition of bank material.

Vegetation Characteristics

Table 3.2 lists all dominant plant species noted on the data forms during the mapping effort for the study area. Species are identified with their common and scientific names, wetland indicator status (USFWS 1988), and whether the species is native to Utah or introduced (NRCS 2009). A total of 41 different species were noted during Red Butte Creek mapping work, with a little more than half of the species being native to Utah. As seen in Table 3.3, most of the nonnative species within the corridor occur

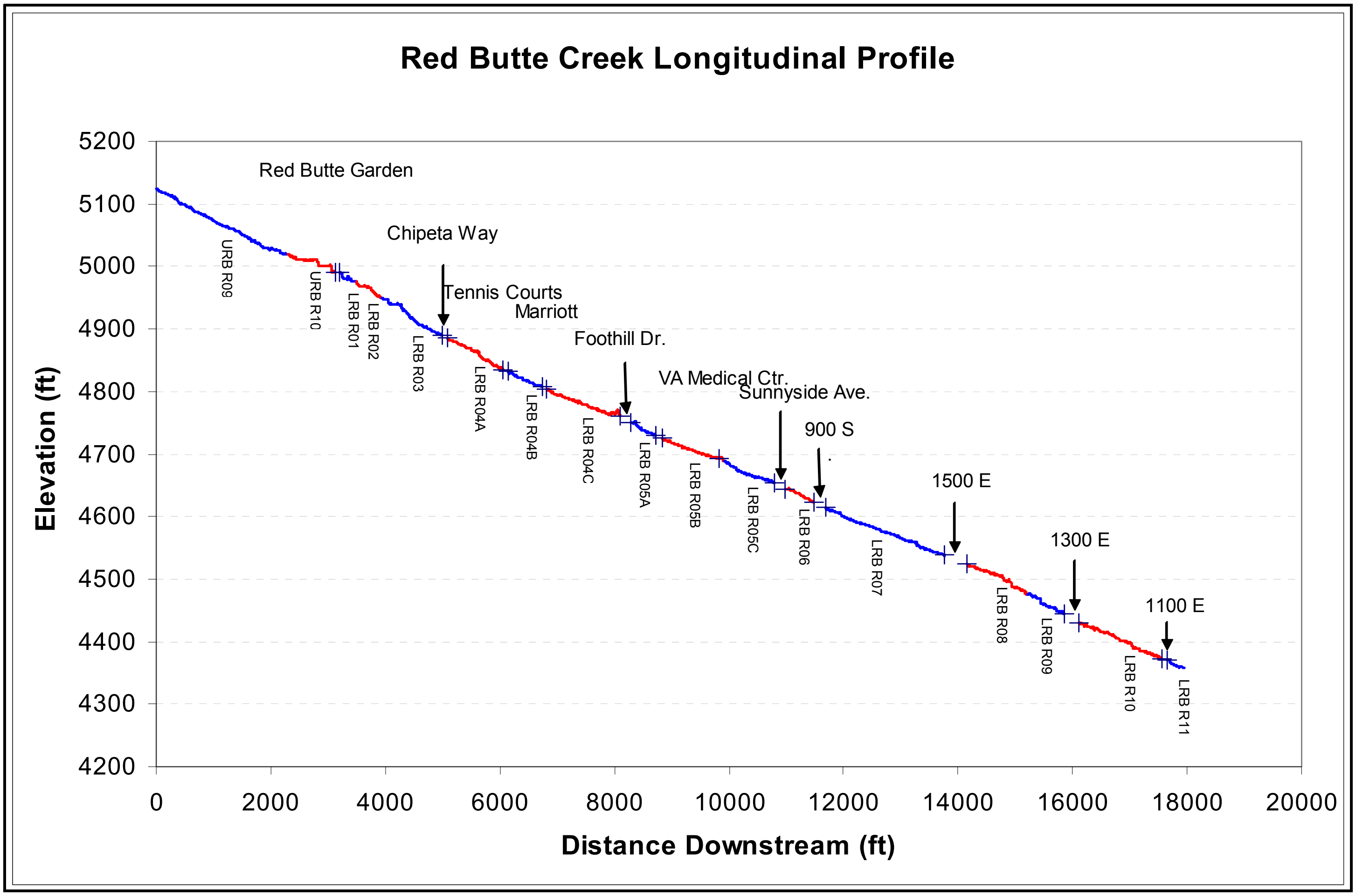


Figure 3.11. Longitudinal profile plot of Red Butte Creek streambed. Black cross marks indicate culvert inlets or outlets; red and blue lines indicate open channel stream sections.

in the canopy and understory vegetation layers while the shrub layer is dominated entirely by native species. The most common trees along the stream-side areas of Red Butte Creek are box elder (*Acer negundo*) and cottonwood (*Populus* sp.), with Gambel oak (*Quercus gambelii*) dominant in undeveloped upper slope areas. Siberian elm (*Ulmus pumila*), an introduced invasive tree species, is fairly common in the study area. Russian olive (*Elaeagnus angustifolia*), also an introduced invasive tree, is present but less prominent (Table 3.3). Common shrub species include redosier dogwood (*Cornus sericea*), twinberry honeysuckle (*Lonicera involucrata*), and narrowleaf willow (*Salix exigua*), with Woods' rose (*Rosa woodsii*) common on upper portions of slopes. The understory vegetation layer includes native species such as Western poison ivy (*Toxicodendron rydbergii*) and Virginia creeper (*Parthenocissus quinquefolia*) in some reaches, with field horsetail (*Equisetum arvense*) present in others. Introduced species such as ornamental English ivy (*Hedra helix*), common periwinkle (*Vinca minor*), climbing nightshade (*Solanum dulcamara*), smooth brome (*Bromus inermis*), and lesser burdock (*Arctium minus*) are significant components of the understory cover in several reaches. In addition, the upper slope portions of some reaches contain the invasive species whitetop (*Cardaria draba*) and houndstongue (*Cynoglossum officinale*) (Table 3.3).

Canopy (tree) cover is generally high throughout the study area,

Table 3.2. Dominant species noted during Red Butte Creek vegetation mapping work.

SCIENTIFIC NAME	COMMON NAME	WETLAND INDICATOR STATUS	NATIVE TO UTAH OR INTRODUCED
Acer grandidentatum	bigtooth maple	no indicator	native
Acer negundo	box elder	facultative wetland	native
Agoseris glauca	pale agoseris	facultative upland	native
Ambrosia artemisiifolia	annual ragweed	facultative upland	native
Arctium minus	lesser burdock	no indicator	introduced
Balsamorhiza macrophylla	cutleaf balsamroot	no indicator	native
Balsamorhiza sagittata	arrowleaf balsamroot	no indicator	native
Betula occidentalis	water birch	facultative wetland	native
Bromus inermis	smooth brome	no indicator	introduced/naturalized
Bromus tectorum	cheatgrass	no indicator	introduced
Cardaria draba	whitetop	no indicator	introduced
Cornus sericea	redosier dogwood	facultative wetland	native
Cynoglossum officinale	gypsyflower (houndstongue)	*not designated*	introduced
Elaeagnus angustifolia	Russian olive	facultative	introduced
Elymus repens	quackgrass	facultative upland	introduced
Equisetum arvense	field horsetail	facultative	native
Fraxinus pennsylvanica	green ash	facultative wetland	native
Gleditsia tricanthos	honeylocust	facultative	native
Hedera helix	English ivy	no indicator	introduced
Juglans nigra	black walnut	*not designated*	native
Lonicera involucrata	twinberry honeysuckle	facultative	native
Maianthemum racemosum	feathery false lily of the valley	no indicator	native
Mahonia repens	creeping barberry	no indicator	native
Maianthemum stellatum	starry false lily of the valley	facultative	native
Melilotus officinalis	yellow sweetclover	facultative upland	introduced
Onopordum acanthium	scotch cottonthistle	no indicator	introduced
Parthenocissus quinquefolia	Virginia creeper	*not designated*	native
Phalaris arundinacea	reed canarygrass	obligate wetland	native
Populus angustifolia	narrowleaf cottonwood	facultative	native
Populus deltoides	eastern cottonwood	facultative wetland	native
Poa pratensis	Kentucky bluegrass	facultative upland	introduced
Prunus virginiana	western chokecherry	facultative upland	native
Quercus gambelii	Gambel oak	obligate upland	native
Rhus trilobata	skunkbush sumac	no indicator	native
Rosa woodsii	Woods' rose	facultative	native
Salix exigua	narrowleaf willow	obligate wetland	native
Solanum dulcamara	climbing nightshade	facultative	introduced
Symphyotrichum ascendens	western aster	no indicator	native
Toxicodendron rydbergii	western poison ivy	facultative upland	native
Ulmus pumila	Siberian elm	no indicator	introduced
Vinca minor	common periwinkle	no indicator	introduced

Table 3.3. List of mapped canopy, shrub, and understory plant species found in each assessed stream reach.

PLANT SPECIES			URB_R09	URB_R10	LRB_R01	LRB_R02	LRB_R03	LRB_R04A	LRB_R04B	LRB_R04C	LRB_R05A	LRB_R05B	LRB_R05C	LRB_R06	LRB_R07
	Common Name	Scientific Name													
CANOPY	Bigtooth maple	*Acer grandidentatum*											X	X	X
CANOPY	Box elder	*Acer negundo*	X	X	X	X	X	X	X	X	X	X	X	X	X
CANOPY	Water birch	*Betula occidentalis*	X	X											
CANOPY	Green ash	*Fraxinus pennsylvanica*										X	X		
CANOPY	Black walnut	*Juglans nigra*										X		X	
CANOPY	Narrowleaf cottonwood	*Populus angustifolia*			X		X								X
CANOPY	Eastern cottonwood	*Populus deltoides*			X			X	X			X	X	X	X
CANOPY	Gambel oak	*Quercus gambelii*	X			X	X	X	X	X			X		X
CANOPY	Honeylocust	*Gleditsia tricanthos*											X		X
CANOPY	Siberian elm [a]	*Ulmus pumila* [a]						X			X	X	X		X
CANOPY	Russian olive [a]	*Elaeagnus angustifolia* [a]					X					X	X		
SHRUB	Western chokecherry	*Prunus virginiana*	X										X		
SHRUB	Skunkbush sumac	*Rhus trilobata*											X		
SHRUB	Redosier dogwood	*Cornus sericea*	X	X	X	X	X	X	X						
SHRUB	Twinberry honeysuckle	*Lonicera involucrata*	X										X	X	X
SHRUB	Woods' rose	*Rosa woodsii*	X		X			X	X	X		X		X	X
SHRUB	Narrowleaf willow	*Salix exigua*			X							X	X		
SHRUB	Creeping barberry	*Mahonia repens*	X			X	X								
UNDERSTORY	Arrowleaf balsamroot	*Balsamorhiza sagittata*	X												
UNDERSTORY	Cutleaf balsamroot	*Balsamorhiza macrophylla*	X												
UNDERSTORY	Field horsetail	*Equisetum arvense*	X									X			
UNDERSTORY	Feathery false lily of the valley	*Maianthemum racemosum*									X				
UNDERSTORY	Starry false lily of the valley	*Maianthemum stellatum*	X												
UNDERSTORY	Virginia creeper	*Parthenocissus quinquefolia*									X	X			
UNDERSTORY	Kentucky bluegrass	*Poa pratensis*	X										X		
UNDERSTORY	Climbing nightshade	*Solanum dulcamara*											X		
UNDERSTORY	Western aster	*Symphyotrichum ascendens*					X								
UNDERSTORY	Western poison ivy	*Toxicodendron rydbergii*					X	X	X	X					
UNDERSTORY	Smooth brome [b]	*Bromus inermis* [b]								X			X		
UNDERSTORY	Lesser burdock [a]	*Arctium minus* [a]	X	X		X	X								
UNDERSTORY	Whitetop [a]	*Cardaria draba* [a]	X							X			X	X	
UNDERSTORY	Quackgrass [a]	*Elymus repens* [a]								X					
UNDERSTORY	Scotch cottonthistle [a]	*Onopordum acanthium* [a]													X
UNDERSTORY	Gypsyflower (Houndstongue) [a]	*Cynoglossum officinale* [a]		X											
UNDERSTORY	Cheatgrass [c]	*Bromus tectorum* [c]												X	X
UNDERSTORY	Common periwinkle [c]	*Vinca minor* [c]												X	X
UNDERSTORY	English ivy [c]	*Hedera helix* [c]												X	X
UNDERSTORY	Yellow sweetclover [b]	*Melilotis officianalis* [b]											X		
UNDERSTORY	Pale agoseris	*Agoseris glauca*											X		
UNDERSTORY	Reed canarygrass	*Phalaris arundinacea*											X		
UNDERSTORY	Annual ragweed	*Ambrosia artemisiifolia*											X		

[a] State- or city-listed, nonnative, noxious weed species.
[b] Species not native to Utah.
[c] Nonnative, invasive species.

Vegetation associations present in the study area:

- Bigtooth Maple / Gambel Oak Forest
- Box Elder - Eastern Cottonwood / Redosier Dogwood Forest
- Box Elder - Eastern Cottonwood Semi-natural Woodland
- Box Elder - Narrowleaf Cottonwood / Redosier Dogwood Forest
- Box Elder / Gambel Oak Woodland
- Box Elder Forest
- Box Elder Semi-natural Woodland
- Designed Ornamental Semi-natural Perennial Mix
- Gambel Oak / Skunkbush Sumac Woodland
- Gambel Oak Forest
- Introduced Trees, Shrubs and Grasses
- Mixed Semi-natural Introduced Forbes and Grasses

with all but six of the mapped vegetation polygons having a percent canopy cover greater than 75%. Because of the high quality tree cover within the Red Butte Creek riparian corridor, the riparian functions of shading and water temperature control are being met to a high degree within the corridor. In contrast, plant cover within the lower structural layers is typically much lower, with 23 and 21 of the mapped polygons having cover of 50% or less in the shrub and understory communities, respectively (Table 3.4). Invasive species cover was variable throughout the study area, with about half of the vegetation polygons having an invasive species class of "low" or "none" (i.e., 5% cover or less), with the other half classified as moderate, high, or majority invasive cover (Table 3.4).

Issues Affecting Riparian Functions

During the baseline assessment work, several common issues were observed to be affecting and limiting riparian functions in the Red Butte Creek corridor. These issues are discussed by function below.

Aesthetics

Although many visually appealing portions of Red Butte Creek exist, the presence of trash and debris degrades corridor aesthetics in a number of locations. Common types of trash include miscellaneous small items such as bottles, cans, food wrappers, plywood, plastic containers, tarps, etc. Another common category of trash is remnant/obsolete infrastructure such as pieces of concrete and asphalt, broken fencing, old pipes and barrels, obsolete erosion-control devices such as failing silt fence, etc. In many instances the concrete pieces are associated with prior bank stabilization efforts that have failed due to the concrete being undermined by scour or streambed lowering. Twelve individual, significant litter areas were mapped in the study area during RCS baseline assessment work.

Table 3.4. **Percent cover and invasive species class for mapped vegetation polygons.**

REACH	POLYGON NUMBER	PERCENT CANOPY COVER	PERCENT SHRUB COVER	PERCENT UNDERSTORY COVER	INVASIVE SPECIES CLASS
LRB_R01	1	76–100+	76–100+	0	none
LRB_R02	2	76–100+	0	0	none
LRB_R02/3	3	76–100+	51–75	1–5	low
LRB_R03	4	51–75	51–75	26–50	low
LRB_R04A	5	76–100+	51–75	51–75	moderate
LRB_R04A	6	76–100+	0	26–50	none
LRB_R04B	7	76–100+	51–75	6–25	none
LRB_R04B	8	76–100+	6–25	0	none
LRB_R04B	9	76–100+	26–50	6–25	none
LRB_R04B	10	76–100+	26–50	6–25	none
LRB_R04C	11	51–75	26–50	26–50	none
LRB_R04C	13	76–100+	26–50	76–100+	high
LRB_R04C	14	76–100+	26–50	76–100+	high
LRB_R05A	15	76–100+	0	26–50	high
LRB_R05B	16	76–100+	6–25	6–25	moderate
LRB_R05B	17	76–100+	6–25	6–25	low
LRB_R05C	18	76–100+	26–50	0	moderate
LRB_R05C	19	76–100+	51–75	6–25	moderate
LRB_R07	20	76–100+	0	26–50	high
LRB_R07	21	76–100+	26–50	76–100+	majority
LRB_R06	22	76–100+	6–25	51–75	majority
URB_R10	23	0	0	76–100+	none
URB_R10	24	51–75	51–75	6–25	moderate
URB_R09	25	76–100+	6–25	51–75	low
URB_R09	26	76–100+	76–100+	51–75	moderate
LRB_R04A	60	76–100+	51–75	26–50	none
LRB_R05C	201	26–50	0	76–100+	high
LRB_R05C	202	76–100+	0	76–100+	high
LRB_R05C	203	26–50	0	76–100+	moderate
LRB_R05C	204	76–100+	26–50	6–25	moderate
LRB_R05C	205	76–100+	26–50	6–25	moderate
LRB_R05C	206	76–100+	26–50	6–25	low

Invasive plants of concern in the study area:

- Russian olive
- Siberian elm
- tree of heaven
- lesser burdock
- whitetop
- periwinkle vine
- English ivy
- cheatgrass
- quackgrass
- Scotch thistle
- houndstongue

Factors limiting shrub and understory cover:

- oversteepened slopes
- inadequate revegetation efforts following construction
- soil compaction from heavy foot traffic
- uncontrolled runoff from upland areas

Wildlife Habitat and Connectivity

A wide range of native bird and mammal species rely on native insects as a key food source (Tallamy 2009). These insects must share an evolutionary history with plants in order to recognize them and use them as a food source. Therefore, healthy native plant communities are necessary for a riparian corridor to function to its maximum potential in terms of wildlife habitat. As discussed above, invasive nonnative plant species are a concern in about half of the study reaches within the Red Butte Creek corridor, and they affect the composition of the understory and canopy vegetation layers. In some areas invasive species comprise the majority plant cover within a vegetative layer, limiting the ability of native plants to thrive and support native insects, birds, and wildlife. The lack of understory and shrub cover in many reaches also limits habitat quality in terms of structural diversity, which is particularly important for bird populations.

Another issue affecting wildlife habitat, as well as riparian connectivity, is the presence of stream crossing culverts. Twelve culvert crossings were mapped within the study area (Figure 3.11). Several of these culverts impede or block fish passage due to steep vertical drops at their outlets and high flow velocities within the smooth concrete pipes. This limits the ability of fish populations to use Red Butte Creek as a continuous travel corridor. The small diameter of the culverts also blocks passage by mammal species such as deer. Within the study area, a total length of 0.35 mile of stream is contained in culvert pipes, limiting the overall length of open channel stream available as aquatic habitat. The longest continuous segments of stream in the study area include study reach URB_R09, which is 2,300 feet long; reach LRB_R07, which is 2,080 feet long; a 1,700-foot-long segment between 1500 East and 1300 East; and a 1,500-foot-long segment between Red Butte Garden and Chipeta Way (Figure 3.11).

Nutrient Filtration and Sediment Trapping

As discussed above, many areas of the Red Butte Creek corridor lack the dense understory and shrub cover that are needed to maximize the ability of the riparian corridor to filter sediment, nutrients, and pollutants from storm runoff. In some areas, understory cover is high but the community is dominated by invasive periwinkle or ivy vines. Because these vines have shallow, low-density root and stem systems, they do not serve the filtration function as well as native grass and forb communities would.

Stream Stability

A number of different issues were noted as affecting stream stability within the Red Butte Creek riparian corridor. Specific issues are discussed in the subsections below.

Stream Crossing Culverts

Localized erosion and deposition problems were noted at several of the stream crossing culverts within the study area. Most of the culverts have diameters of 3 to 7 feet (Table 3.5), which is significantly smaller than the 13-foot average bankfull channel width. Because of this width discrepancy, a hydraulic constriction occurs at culvert inlets, slowing flow velocities and leading to deposition and accumulation of sediment and debris. At three crossings within the study area, the size of the openings at the culvert inlets and the conveyance capacities of the structures have been substantially reduced as a result of this deposition process. During RCS public workshops and stakeholder meetings, no one reported experiencing any flooding problems on Red Butte Creek since the 1983 floods; however, problems may occur in the future unless measures are taken to restore the conveyance capacities of these crossing structures.

The size and design of the stream crossing culverts also contribute to stability concerns at some of the culvert outlets. During high flows, velocities at the outlets of the longer culverts are accelerated because of width constriction and a lack of bed roughness within the smooth concrete pipe material. Scour problems and vertical drops were noted at three of the assessed crossing outlets within the study area (Table 3.5).

Storm Drain Outfalls

Erosion was commonly observed at storm drain pipe outfalls within the study area. These outfalls deliver storm water runoff to the creek from streets, gutters, and rooftops. The outfalls often lack adequate outlet protection to dissipate runoff velocities and protect against erosion. Even where outlet protection is provided, stabilized conveyance channels are typically lacking between the protected outlet and the main Red Butte Creek channel and evidence of rill erosion in these areas is common. Of the 25 mapped outfall locations, 12 were ranked as medium- or high-priority areas for stability improvements.

Top left: Debris and sediment accumulation at culvert inlet. Top right: Erosion at storm drain outfall. Bottom left: Invasive vines on streambank. Bottom right: Scour at culvert outlet.

Table 3.5. Size and condition of stream crossing culverts in the study area.

Crossing Location/ Description	Reach Number(s)	Approximate Culvert Length (ft) [a]	Vertical Drop from Inlet to Outlet [b] (ft) [a]	Culvert Type	Approximate Culvert Size/ Diameter (ft) [a]	Inlet Condition	Outlet Condition
Trail at south end of Red Butte Garden	between LRB_R01 and LRB_R02	50	2	3 round pipes	2.5 each	fair; affected by silt fence/construction at time of assessment	good; minimal scour
Chipeta Way	between LRB_R03 and LRB_R04A	108	5	concrete arch	6.5 H x 5.5 W [c]	fair; sticks placed across inlet	good; minimal scour
Crossing near tennis courts	between LRB_R04A and LRB_R04B	90	4	concrete arch	7 H x 6 W [c]	fair; boards partially block inlet	good
Crossing near Marriot	between LRB_R04B and LRB_R04C	72	4	concrete arch	6 H x 6 W [c]	fair; partially blocked by sediment/debris accumulation	good
Foothill Drive	between LRB_R04C and LRB_R05A	192	9	concrete box (inlet); eliptical metal pipe (outlet)	6.5 H x 6 W (inlet); 6 H x 7 W (outlet) [c]	fair; bare slopes around concrete headwall	poor; scour and bank erosion; 2-foot drop from pipe to water surface
Hall Street	between LRB_R05A and LRB_R05B	128	5	round concrete pipe	6	fair; some bare slopes/erosion around concreteheadwall	fair; scour pool present below concrete apron
Crossing within VA Medical Center complex	near downstream end of LRB_R05B	20	1	concrete arch	5	poor; nearly blocked by sediment and debris	poor; 2/3 of arch filled with sediment
Sunnyside Avenue	between LRB_R05C and LRB_R06	180	10	two vertically stacked concrete boxes	each 3 H x 3 W [c]	good	not assessed
900 South	between LRB_R06 and LRB_R07	210	9	round metal pipe	3	not assessed	fair; some scour/ undercutting
Trail in Miller Park	middle of LRB_R07	16	N/A [d]	open-bottom arch	9 H x 12 W [c]	excellent	excellent
1500 East	between LRB_R07 and LRB_R08	400	14	round concrete pipe	4	stable; concrete and rip-rap	not assessed
1300 East	between LRB_R09 and LRB_R10	260	14	round concrete pipe	3 or 4	not assessed	not assessed
1100 East	between LRB_R10 and LRB_R11	90	1.5	round concrete pipe	3 or 4	stable; all concrete	stable; all concrete

[a] Feet.
[b] Elevation change between inlet and outlet based on digital elevation data.
[c] H = height, W = width.
[d] Not applicable.

Streambank Erosion

Lateral erosion of streambanks is a natural process in stream channels, which are dynamic systems. Erosion and sediment transport are necessary for the creation and maintenance of important habitat features such as scour pools, undercut banks, and spawning gravels. Deposition of sediment onto floodplain areas is also important, as it provides fresh substrate for the growth of willow and cottonwood seedlings that are needed to maintain native riparian forests. However, excessive amounts of erosion or deposition can degrade habitat and water quality, and threaten municipal infrastructure and residential homes.

Several types of bank erosion were observed in the study area. Low bank erosion/root zone scour are evident in nearly all study reaches and are associated with the flashy urban hydrology that produces frequent, erosive runoff events during storms. In some areas, it appears that streambed lowering is also contributing to low bank erosion by causing the toe of the slope to become undermined. In some reaches tall, vertical, bare banks are present where the creek has migrated laterally into a fine-grained Bonneville terrace deposit. This type of terrace erosion at the outside of bends is a natural process, but it is a concern where it poses a risk to infrastructure. Localized bank erosion caused by direct channel alterations is another type of erosion problem observed in the study area. In several locations, bank erosion problems were observed in unprotected areas opposite or adjacent to banks that have been hardened with rock or concrete. This type of problem can occur when bank stabilization efforts are not implemented comprehensively throughout a reach because measures taken to fix erosion in one location may alter channel shape and flow hydraulics and inadvertently create erosion in a different location.

Top: Terrace erosion at outside of bend. Bottom: Low bank/root zone erosion.