3.0 BASELINE ASSESSMENT RESULTS

Watershed Conditions

Size and Land Use

Emigration Creek lies between Red Butte Creek to the north and Parleys Creek to the south (Figure 3.1). The upper subwatershed, located in Emigration Canyon above the debris basin, drains 11,635 acres of mountainous areas with moderate slopes. The upper subwatershed contains about 9 miles of stream from the headwaters to the Emigration Creek debris basin (SLCO 2009). The majority of the upper subwatershed is private land within unincorporated areas of the County. Existing land use is primarily residential and undeveloped forest, with an estimated impervious cover of 12.5%.

The lower Emigration Creek subwatershed is much smaller, draining 3,742 acres of primarily bench area below the canyon

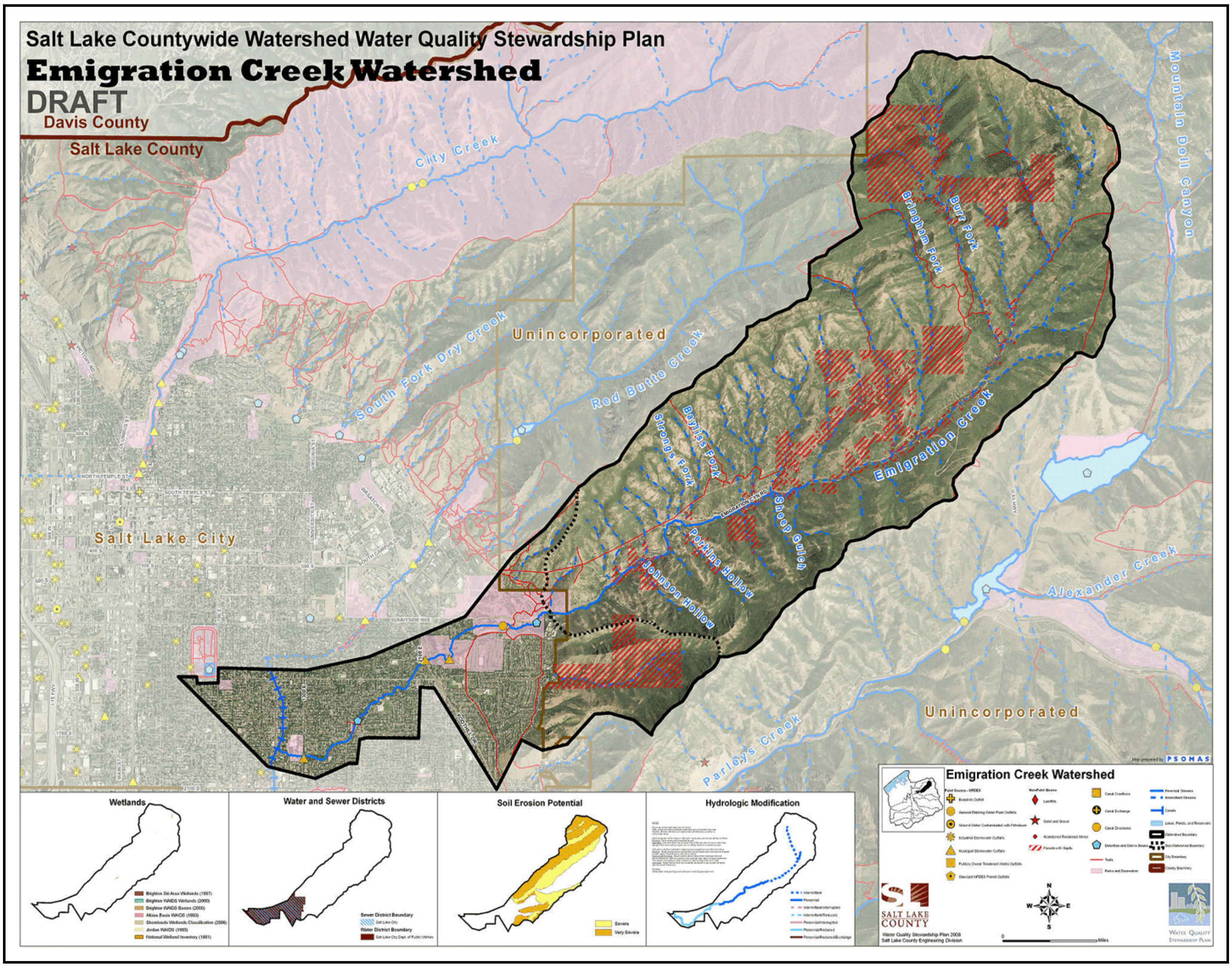


Figure 3.1. Emigration Creek watershed. (Map from SLCO 2009).

mouth. The open channel length of Emigration Creek totals approximately 3.1 miles in the lower subwatershed. About 2.1 total miles of lower Emigration Creek have been piped in underground culverts, including the 1300 South conduit that conveys Emigration Creek from 1100 East to the Jordan River (Figure 1.1). Most of the lower subwatershed is located within the City's municipal boundaries (Figure 3.1). Existing land use is primarily residential, with some smaller areas of park land and commercial development. Estimated impervious cover is 23.2% within the lower subwatershed.

Hydrology

Because of natural alluvial deposition patterns, Wasatch Mountain streams—including Emigration Creek—naturally lose some surfaceflow to groundwater where the canyons transition to the valley. Within the RCS study area, Emigration Creek flows through areas mapped as primary and secondary groundwater recharge zones, and studies have estimated losses to groundwater to be around 11% of runoff (SLCO 2009). 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).

The headwater portion of Emigration Creek is classified as having intermittent flow; below Perkins Hollow the creek is classified as perennial (Figure 3.1, SLCO 2009). The County classifies flows in Emigration Creek from reach LEM_R02A downstream as "perennial-reduced," indicating that flows are artificially reduced by stream diversions. Within the study area, recorded points of diversion from Emigration Creek include the downstream end of reach LEM_R02A within Hogle Zoo and a point near the middle of reach LEM_R10 in the Wasatch Hollow area (UDWRT 2009). Water rights holders include a mix of local and State government entities, Mt. Olivet Cemetery, and other private individuals and companies.

Although the stream is classified as perennial above reach LEM_R02A, the creek was dry in reach UEM_R16 during RCS field work conducted in October 2008. Various diversions from Emigration Creek and its

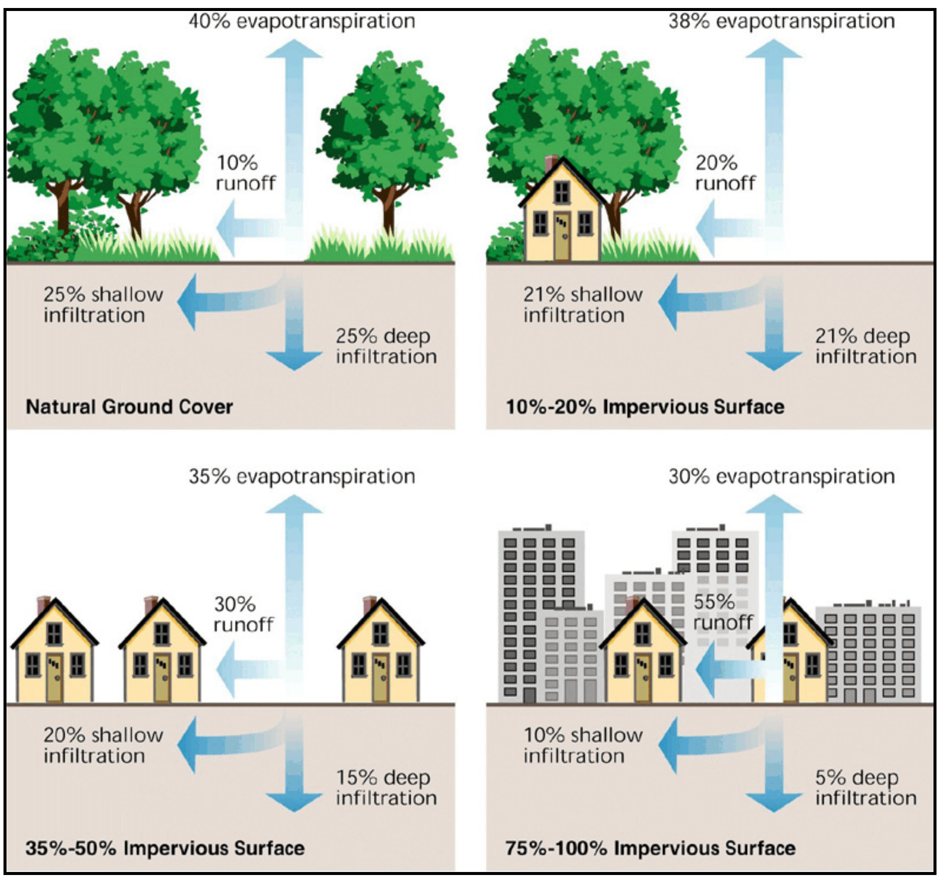


Figure 3.2. Relationship between impervious cover and surface runoff. Impervious cover in a watershed results in increased surface runoff. (Diagram and caption text from FISRWG 1998).

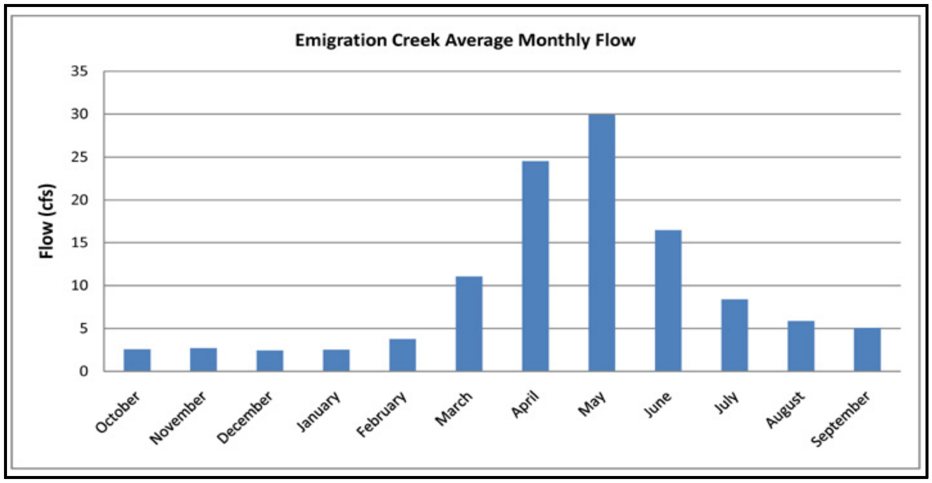


Figure 3.3. Monthly flows at Salt Lake County's gage at Rotary Glen Park.

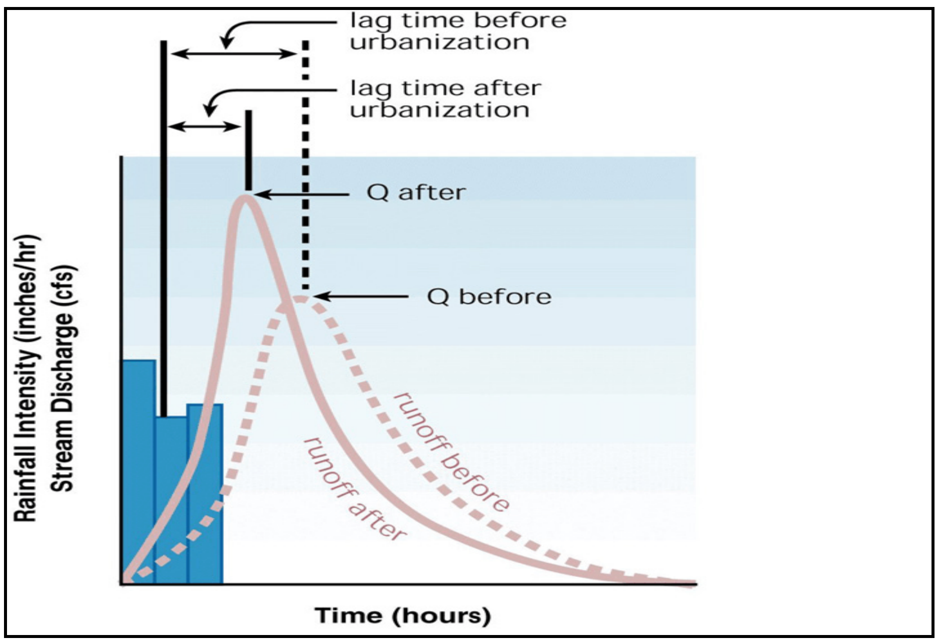


Figure 3.4. A comparison of hydrographs before and after urbanization. The discharge curve is higher and steeper for urban streams than for natural streams. (Diagram and caption text from FISRWG 1998).

tributary springs occur within Emigration Canyon, and some return flows from septic systems also occur in this area. At the RCS public workshops, residents of the lower portions of the creek repeatedly indicated concerns about summertime reduced flows and flow fluctuations apparently associated with diversion operations. Reduced summertime baseflows on lower Emigration Creek are most likely the result of a combination of factors including urbanization effects on hydrology, flow diversions, and natural surface water losses to alluvial deposits.

Emigration 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 in Rotary Glen Park from 1980–2005, average monthly flow is highest in May (Figure 3.3), and peak daily flow occurs on May 1 on average (SLCO 2009). Average annual high flow is 55 cubic feet per second (cfs), while typical base flows are on the order of 2.5 cfs. No streamflow gage exists at the downstream end of the study area, so no quantitative data are available to characterize hydrology after the creek flows through the most urbanized portion of watershed downstream from the Rotary Glen Park gage. However, 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). Flow patterns at the Rotary Glen Park gage show a more moderated response during storm events.

No significant water storage reservoirs are present on Emigration Creek, but sediment supply to the lower reaches is altered by the Emigration Creek debris basin, an on-stream facility located in Rotary Glen Park (Figure 2.1). The debris basin was originally constructed in 1985, and it is maintained by the County. The facility traps the

Below: Emigration Creek debris basin in Rotary Glen Park.

majority of coarse sediment loads and typically requires dredging to remove accumulated material about every 2 years.

Water Quality

Between Foothill Drive and its headwaters, Emigration Creek's beneficial use classifications (as designated by the Utah Division of Water Quality [DWQ]) include 2B (secondary contact recreation) and 3A (cold water fishery). Below Foothill Drive, the creek is designated with the default classifications of 2B and 3D (waterfowl/shorebird protection). The DWQ has listed a segment of Emigration Creek above Foothill Drive as impaired for E. coli bacterial contamination (DWQ 2006). The number of residential septic systems in the upper subwatershed is most likely a significant contributing source of E. coli to the stream (SLCO 2009). Other potential nonpoint sources of pollution in the lower subwatershed include urban runoff, hydrologic modification and habitat alteration, managed park and golf course areas, and construction runoff (SLCO 2009).

Emigration Creek was originally listed as impaired for high fecal coliform levels in 2000; however, with a change in state standards, E. coli is now the target parameter. The County and DWQ have collaborated to conduct a Total Maximum Daily Load (TMDL) study for E. coli in Emigration Creek and have been collecting monthly samples since January 2007. Water temperature, dissolved oxygen, and pH data are collected in conjunction with the monthly E. coli samples, and more intensive weekly samples are collected for 5 weeks in August/September. Six DWQ water quality monitoring stations are being used for the TMDL studies (H. Arens 2009, pers. comm.). Four of the monitoring stations are located upstream of the RCS study area, one is located in reach UEM_R17 (STORET 4992145), and one is located near the Rotary Glen Park streamflow gage in reach LEM_R01 (STORET 4992140). In summer 2008, a separate but related microbial source-tracking study to identify fecal contamination sources was performed by Dr. Ramesh Goel, who was contracted through the County. The final report for that study is expected in summer 2009. The Emigration Creek TMDL study is ongoing and expected to be complete in April 2010. Once complete, the TMDL plan will include a list of implementation measures to achieve water quality targets and re-attain full support of water quality standards.

No established DWQ water quality monitoring stations are present on Emigration Creek downstream from the Rotary Glen Park station. However, as part of ongoing TMDL studies on the Jordan River, data are being collected 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 will provide an indication of water quality conditions and storm water effects within the lower, urbanized portions of these creeks.

Geology and Soils

The uppermost reaches of Emigration Creek flow through members of the Cretaceous Kelvin formation, which includes limestone, conglomerate, and sandstone components. The creek then flows past Preuss Sandstone and Twin Creek Limestone, both Jurassic formations (Bryant 1990). Approximately 50–86.2% of the soils in the upper Emigration Creek subwatershed have severe to very severe soil-erosion potential. Once it exits the canyon, Emigration Creek flows through a series of Pleistocene Lake Bonneville deposits ranging from finer-grained silt and clay deposits to coarser sand and gravel deposits (Bryant 1990). 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, Emigration 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-induced 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 Emigration Creek are limited. However, known populations of native Bonneville cutthroat trout (*Oncorhynchus clarki utah*) and introduced rainbow trout (*Oncorhynchus mykiss*) exist in upper Emigration Creek, and Bonneville cutthroat trout populations exist in lower Emigration Creek (SLCO 2009). During the RCS field assessments, trout were observed in several scour pools at the outlets of stream-crossing culverts. At the RCS public workshops, residents reported observations of fish, deer, fox, and a wide variety of bird species within the riparian corridor. Nuisance species, including racoons and skunks, are also regularly seen.

Reach LEM_R02D, just upstream of the Bonneville Golf Course, is used as a site for the Audubon Society's annual Christmas bird count. During the 2005 Christmas bird count, 24 different bird species were observed within the East Bench survey area, which includes portions of the Emigration Creek riparian corridor (Carr 2009). The RCS workshop attendees expressed an interest in knowing more about the existing populations of wildlife within the corridor.

Historical Conditions and Current Trends

Emigration Creek History

Emigration Canyon holds a prominent place in Utah's history, as it was the route through which Mormon pioneers first entered Salt Lake Valley in 1847. Although detailed descriptions, drawings, and photographs specific to the riparian corridor are limited, available information suggests that the corridor at that time was a dense thicket of willows, scrub oak, and tall grasses (Figure 3.5). The Donner-Reed Party traveled through Emigration Canyon in 1846 on their way to California. They found the brush along the creek bottom so impenetrable that near the mouth of the canyon they opted to climb up and over the steep hill to the south, a decision that exhausted their livestock and likely contributed to their tragic fate in the California mountains (USHD 2009). Pioneer accounts also describe a marsh near the current Hogle Zoo location that hindered travel (Dixon 1997).

These available historical descriptions suggest that the overall vegetation density, grass cover, and shrub cover along Emigration Creek was substantially greater 160 years ago than it is today. The description of a marsh near

1847

First party of Mormon Pioneers enter Salt Lake Valley via Emigration Canyon.[1]

Early accounts describe the creek as a "gulch" with "shoulder-high grasses and nearly impenetrable brush in the creek bed."[1, 3]

William Clayton wrote an account of scaring a bear at the mouth of Emigration Canyon while working on the road. Others mention large rattlesnakes, ducks, sandhill cranes, black crickets, and deer and antelope signs. John Steele mentions spotting four "wolves" at the mouth of Emigration Canyon.[1, 2]

"The Mormon wagons, in short, kept down the gulch of Emigration to a point immediately above the present Hogle Gardens Zoo, then to avoid a marsh in the bottoms, pulled up on the benchland to the south." [3]

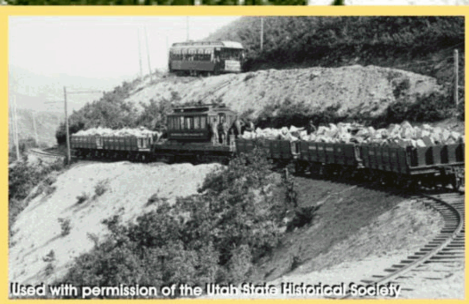
- Dale Morgan

Thomas Bullock recounts backtracking from campsites on the banks of Parley's Creek, likely to avoid the marshes and tall grass at the convergence of Parley's, Emigration, and Red Butte Creeks.[3]

1907 - 1917

Because of pollution from sheep and livestock, City officials decided not to designate the Emigration Creek watershed for water supply, thereby opening the area to development.[1]

Emigration Canyon Railroad connected Salt Lake City to sandstone quarries in the canyon. These resources supported the city's building boom. The railroad included passenger cars, which promoted construction of summer cabins in the canyon.[5]



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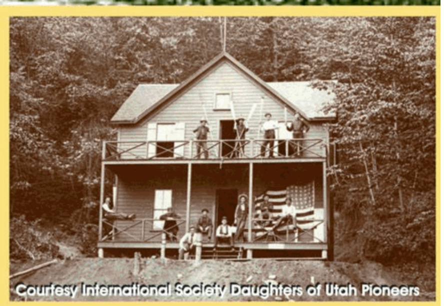


Courtesy International Society Daughters of Utah Pioneers

1927

"Near the foothills there were two reservoirs – Sunnyside and Baskins. Lynn Layton said in 1927 the dam broke and this altered Emigration Creek." [6]

- from Jean Thornton's notes

Fish in the Emigration Canyon stream were also plentiful. Bill remembers that in drought years, fish would collect in water holes. They could easily be caught and transported back home in wooden barrows.[1]

Figure 3.5. Emigration Creek historical timeline.

1847 - 1900

"As we progressed down the Valley, small Clumps of dwarf Oak, & Willow appear, the Wheat Grass grows 6 or 7 feet high, many different kind of grass appear, some being 10 or 12 feet high . . ." [4]

- from Thomas Bullock's journal

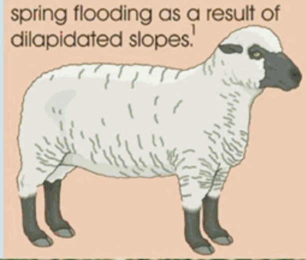
Early development of creek for water supply.[1, 2]

Historical records mention various diversions and ditches to supply farmers.[1, 2]

Springs developed to supply Wagener's Brewery, which operated at the mouth of Emigration Canyon from 1893-1903.[2]

Emigration Tunnel Spring developed for Salt Lake City water supply.[2]

Sheep grazing, introduced to Emigration Canyon through city leases, left the canyon slopes barren, muddy, and dusty, and caused common spring flooding as a result of dilapidated slopes.[1]



Footnotes

1 Carlstrom and Furse 2003
2 Cederlof 1950
3 Dixon 1997
4 http://www.utah.com/mormon/pioneer_trail_history.htm
5 http://historytogo.utah.gov/utah_chapters/mining_and_railroads/emigrationcanyonrailroadservedslcbuildersneeds.html
6 Thornton 1977
7 https://www.hoglezoo.org/about/zoo_history/
8 http://www.ci.slc.ut.us/Utilities/NewsEvents/news2000/news03142000.htm

1931

Mr. and Mrs. James Hogle donate land near Emigration Canyon and Hogle Zoo is relocated to its current site.[7]

A new highway was built, burying the old double road beneath the modern oil surface of State Route 65, which brought Emigration Canyon a bit closer to town.[1]

1940 - 1950

Historical descriptions of 1300 South area of Emigration Creek indicate the channel alignment had been modified.[3]

"The stream had been pushed over to our side with garbage. When Lynn Layton first came here before his house was built, his sons, Bill and Gary dug a small channel in its original place returning it to its rightful place." [6]

- from Jean Thornton's notes

1952

Rain, combined with runoff from a record snow pack, caused flooding of hundreds of Salt Lake City blocks. Residents reported that the culverts of Emigration Creek at 2100 East and 1300 South Streets overtopped and flooded the roads.[8]

1983

Rapid snow melt again caused extensive flooding in spring 1983, with reported flood damages along Parley's, Emigration, and Red Butte Creeks totaling about $10 million.[8]

Hogle Zoo also suggests that the creek was not as deeply entrenched during that time period as it is today. Historical accounts of Emigration Creek describe diverse and abundant fish, bird, and wildlife populations within the riparian corridor (Figure 3.5). Fish, including native cutthroat trout, were plentiful, and fish were stocked into the creek during the 1930s and 1940s (Carlstrom and Furse 2003).

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 Emigration Creek. Among other factors, systematic programs to clear debris from channels and 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 decreased, the “checks” on sediment and water created by beaver dams also decreased, resulting in greater flow velocities and streambed down-cutting. The control and reduction of beaver populations throughout the west has profoundly altered stream channel, floodplain, and riparian vegetation conditions (Wohl 2000).

Many of the direct alterations to Emigration Creek have occurred in order to address flooding concerns and accommodate urban development and population growth. A 1902 newspaper report describes a washout on Emigration Creek that blocked 1100 South for 10 years, illustrating the conflict between efficient transportation and natural flooding processes (Deseret News 1902). 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 Emigration Creek does not appear to have changed dramatically since 1938. Some straightening and bend realignment are evident near the present site of Clayton Middle School (in reach LEM_R09B) and in the Wasatch Hollow area (reach LEM_R10). A more

Historical activities that have altered riparian corridor conditions:

- mining and quarrying for limestone and 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
- sheep grazing
- residential and commercial development
- introduction of invasive, nonnative plants
- piping of the creek in underground conduits
- channel relocation and straightening
- bank armoring
- placement of fill within floodplain areas
- debris basin construction

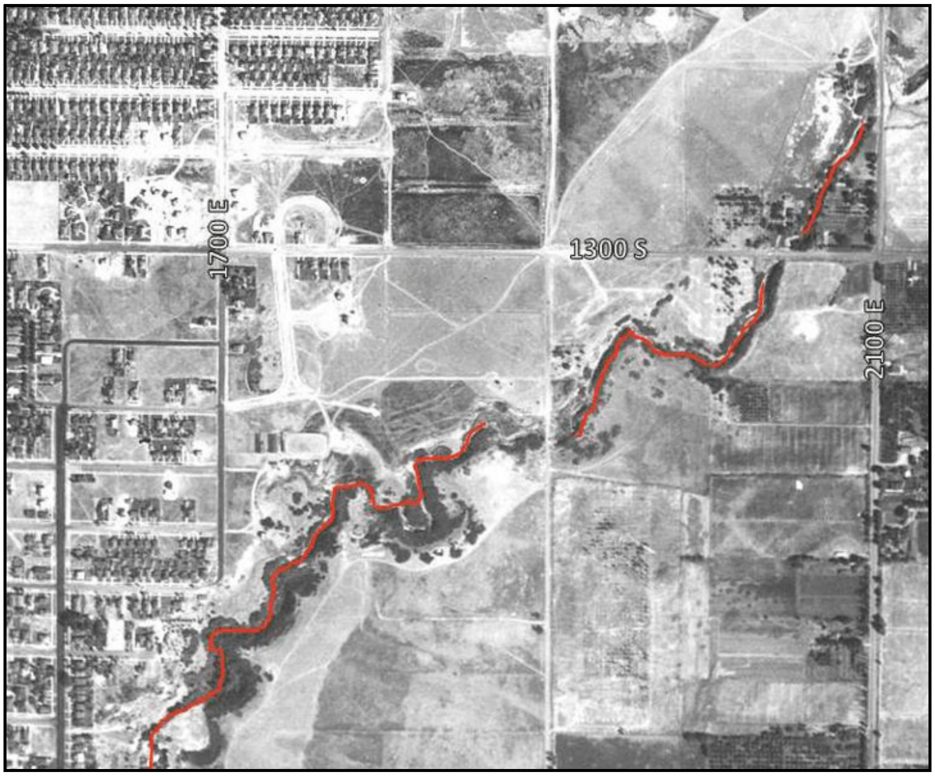


Figure 3.6. **1938 aerial photograph of Emigration Creek from 2100 East to 1700 East. The Photograph is overlaid with 2006 channel alignment in red; gaps in the line indicate underground culverts.**

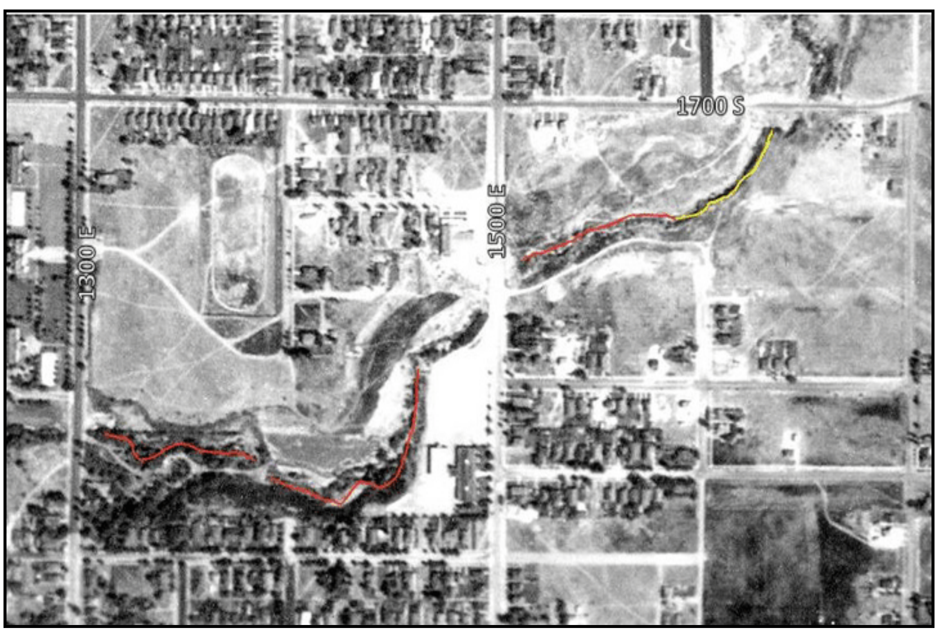


Figure 3.7. **1938 aerial photograph of Emigration Creek from 1700 South to 1300 East. The Photograph is overlaid with 2006 channel alignment in red and yellow; gaps in the line indicate underground culverts.**

significant change is the increase in length and number of culvert pipes since 1938 (Figures 3.6 and 3.7). The 1938 photo shows a continuous open stream channel between 2100 East and what is now Hogle Zoo (Bowman and Beisner 2008); today this stretch of stream is interrupted by six different culvert crossings. The construction of culvert crossings and piping of portions of Emigration 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 since 1938. This is most likely the result of landscaping and tree planting as dense residential neighborhoods were built along the creek. Based on the ages of homes in the corridor, much of the residential development within the RCS study area occurred between about 1940 and 1960.

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, 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 over supply of water relative to sediment supply. These channels have few bar deposits and are commonly downcut (incised) with reduced floodplain access (Figure 3.8). Many of the reaches of Emigration Creek that were assessed exhibit characteristics of the late urbanized phase, such as evidence of down-cutting and low bank erosion/root scour. During the RCS public workshops, a number of residents who live along Emigration Creek indicate that they have observed lowering of the streambed adjacent to their property over the last several decades.

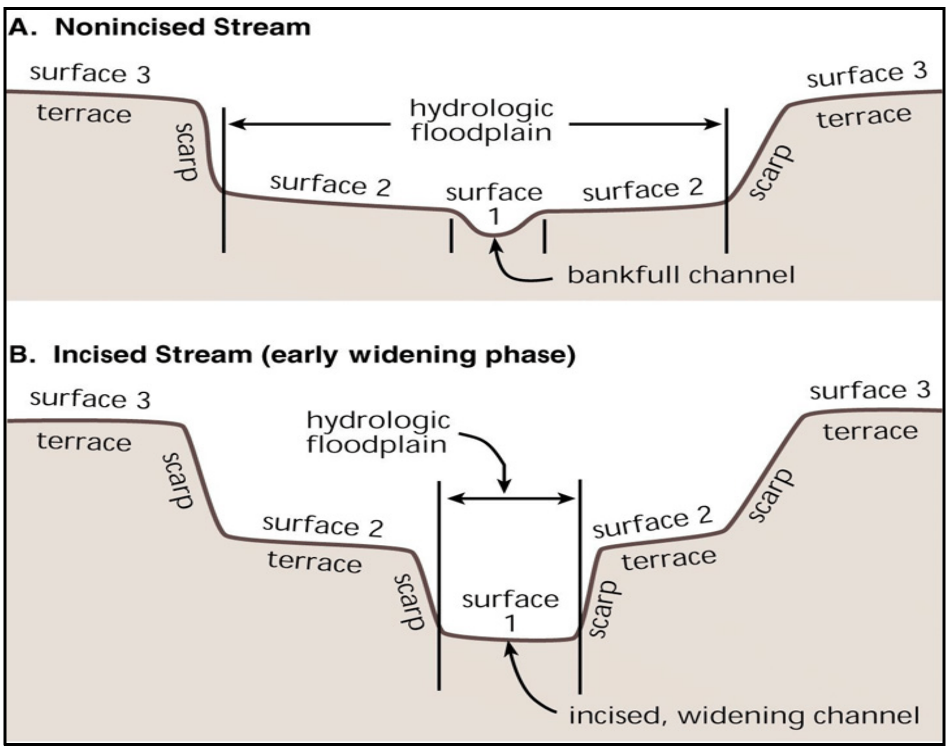


Figure 3.8. Illustration of streambed lowering (incision) process common on urbanized streams. Following initial incision (B), the channel may continue to incise and widen until a new equilibrium channel/floodplain geometry is reached, posing a potential risk to urban development on terrace surfaces adjacent to the channel. (Diagram from FISRWG 1998).

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 Emigration Creek corridor reflect a complex response to a variety of historical and ongoing alterations throughout the watershed. This complexity makes it difficult to distinguish whether channel lowering observed in a specific location is due to a corridor-scale streambed lowering trend, a localized culvert effect, or a combination of several factors.

Recent and Anticipated Future Trends

The residential population of the upper Emigration Creek subwatershed grew dramatically from 1980–2005, with a current population estimate of about 1,200 year-round residents (WRPRP 2009). Development has often involved direct alterations to the stream channel such as construction of new bridge or culvert crossings, bank armoring projects, and channel relocation efforts (UDWRT 2009).

Within the lower Emigration Creek subwatershed, land use predictions for 2030 indicate a increase in impervious cover from 23.2% to 27.7% and a 6% loss of open space. Most of this change is associated with an expected increase in the amount of commercial land use. No impervious surface cover increase is predicted for the upper subwatershed. However, more than 600 currently undeveloped residential lots are present in Emigration Canyon, suggesting a potential for significant further development. There are currently no plans to develop a sewer system in the Upper Emigration Creek subwatershed (SLCO 2009).

Climate change is another factor that can be anticipated to affect the Emigration Creek riparian corridor. Climate projections for the southwest 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, are 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 an anticipated reduction in summertime baseflows (Karl et al. 2009). It is difficult to predict specific changes to Emigration Creek with certainty, but recorded annual stream flow volumes on Emigration Creek show a declining trend between 1970 and 2006 (L. Alserda 2009, pers. comm., Figure 3.9). This trend is anticipated to continue into the future (Karl et al. 2009).

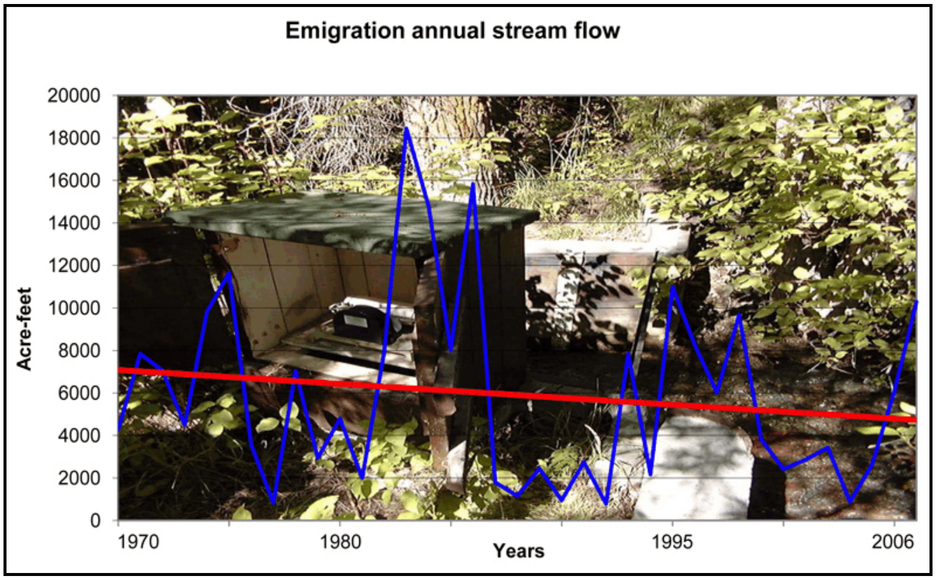


Figure 3.9. Plot of temporal trends in annual stream flow at Emigration Creek gage. Plot provided by the Salt Lake City Department of Public Utilities.

Stream and Vegetation Conditions

Stream Channel Characteristics

Salt Lake County has classified the majority of stream length within the lower Emigration Creek subwatershed as moderately entrenched, meaning the channel is somewhat vertically confined. Over 90% of the channel in the lower watershed received a fair to poor stream stability rating during County stream studies (SLCO 2009). During field assessments in 2008, the County classified lower Emigration Creek as Rosgen (1996) stream type B5 between Rotary Glen Park and Foothill Drive (reaches LEM_R01 through LEM_R05) and stream type B4 below Foothill Drive. The assigned stream type for reaches UEM_R16 and UEM_R17 was also B4 (K. Collins 2009, pers. comm.). County bankfull width estimates for the stream reaches in lower Emigration Creek ranged from 12–37 feet, with an average value of 18 feet. Estimates for reaches UEM_R16 and UEM_R17 were 10 feet and 11 feet, respectively (K. Collins 2009, pers. comm.).

Results of RCS field surveys and GIS analyses further illustrate the fact that the Emigration Creek channel is moderately 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

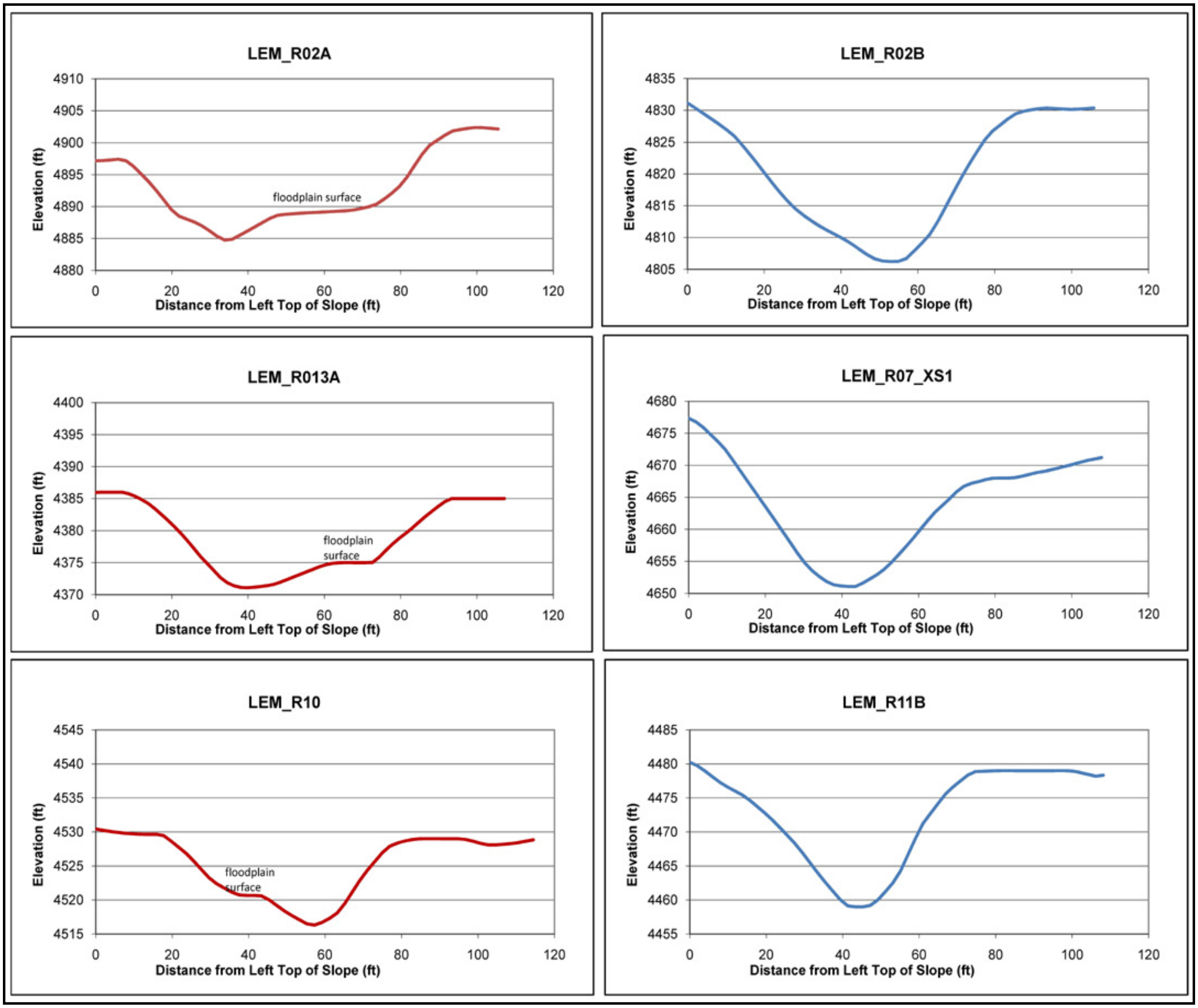


Figure 3.10. Cross-section plots extrapolated from digital elevation data. Plots on left (in red) exhibit less vertical confinement and include relatively well-developed active floodplain surfaces. Plots on right (in blue) exhibit a greater degree of vertical confinement between tall, steep side slopes.

"canyon." 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 and includes larger areas of flat, active floodplain surfaces (Figure 3.10). These surfaces 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 4–14 feet at low flow, with an average value of 10 feet (Table 3.1). In about half of the reaches, field surveys were conducted at a streamflow of 66 cfs, which is close to the average annual high flow value of 55 cfs. Width at this high flow value varies from about 13–26 feet, with an average of 17 feet. In

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 DATA					
	D16 (mm) [a]	D50 (mm) [a]	D84 (mm) [a]	Percent Embedded	Low Flow Wetted Width (ft) [b]	Wetted Width (ft) [b] at 21 cfs [c]	Wetted Width (ft) [b] at 66 cfs [c]	Local Slope (ft/ft) [d]	Reach Slope (ft/ft) [d]	Reach Length (ft) [b]
UEM_R16	5	17	92	21	N/A [e]	9.9	13.8	0.020	0.021	2864
UEM_R17	7	22	49	3	9.1	9.9	-	0.013	0.021	681
LEM_R01	<2	28	59	9	10.9	13.9	18.0	0.007	0.018	1284
LEM_R02A	4	20	70	22	11.9	14.1	-	0.014	0.007	290
LEM_R02B	8	68	181	47	14.8	17.9	-	0.036	0.033	734
LEM_R02C	-	-	-	-	-	-	-	-	0.025	1120
LEM_R02D	5	27	85	10	9.3	12.6	15.5	0.013	0.015	277
LEM_R03A	5	19	46	0	12.2	15.3	-	0.013	0.018	341
LEM_R03B	<2	17	72	15	4.2	8.9	-	0.052	0.023	451
LEM_R04	<2	36	179	27	7.5	11.1	-	0.038	0.029	768
LEM_R05A	<2	37	121	22	13.9	14.7	15.1	0.024	0.016	615
LEM_R05B	<2	34	64	10	5.9	10.5	-	N/A [e]	0.027	317
LEM_R06	12	34	91	16	8.8	16.6	17.6	0.025	0.029	155
LEM_R07_XS1	18	45	104	17	10.6	14.6	15.3	0.027	0.023	674
LEM_R07_XS2	-	-	-	-	5.3	8.7	-	0.045	0.023	674
LEM_R08A	8	43	109	24	12.1	13.7	16.5	0.024	0.025	988
LEM_R08B	20	51	116	14	11.5	13.0	-	0.022	0.020	677
LEM_R09A	<2	32	99	8	11.1	18.6	-	0.037	0.024	579
LEM_R09B	-	-	-	-	-	-	-	-	0.050	264
LEM_R09C	4	15	33	3	10.0	25.9	26.1	0.011	0.021	1248
LEM_R10	6	43	102	14	7.4	11.2	-	0.028	0.012	1121
LEM_R11A	-	-	-	-	-	-	-	-	0.025	520
LEM_R11B	4	37	128	15	10.7	12.6	13.2	0.056	0.020	614
LEM_R12	-	-	-	-	-	-	-	-	0.028	1666
LEM_R13A	13	61	171	28	10.9	14.8	17.3	0.029	0.024	1304

[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] Not applicable.

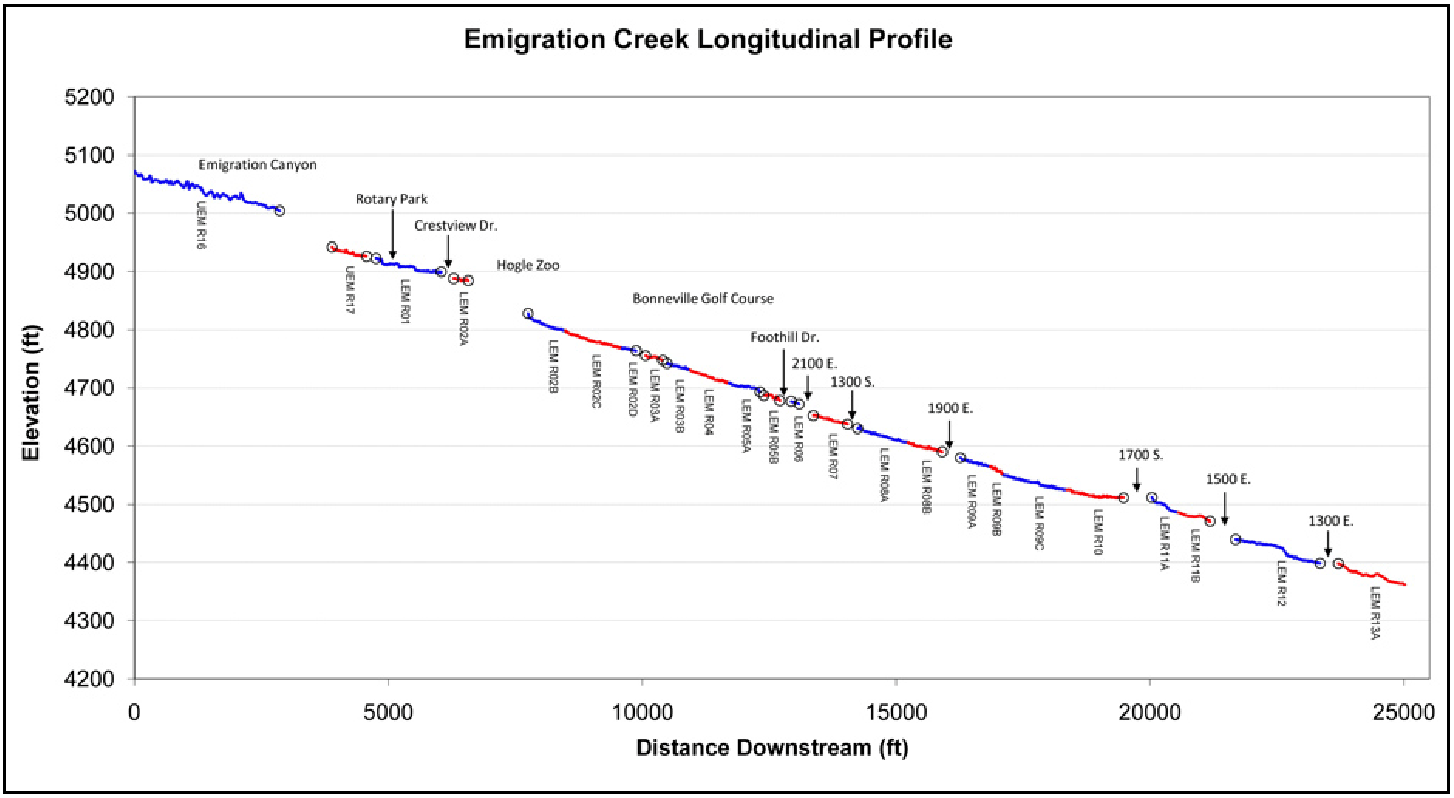


Figure 3.11. Longitudinal profile plot of Emigration Creek streambed. Circles indicate culvert inlets or outlets; red and blue lines indicate open channel stream sections.

some locations, such as LEM_R07 cross-section 2, channel width has been directly affected by installed bank hardening measures.

Channel slope, as determined for each stream reach from digital elevation data, varies from 0.7%–5.0% within the RCS study area, with an average value of 2.0%. (Figure 3.11, Table 3.1).

Emigration 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 the Lake Bonneville bench deposits. The valley becomes significantly flatter west of 1100 East, and historically Emigration 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 (D_{50}) streambed particle size at the measured cross sections ranges from 15–68 millimeters (mm), indicating that medium- and large-sized gravel are the dominant substrate sizes in riffle areas of Emigration Creek (Table 3.1). At most of the cross-section riffles, sand or fine gravel comprises the D_{16} particle size, and cobble-sized material comprises the D_{84} 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, composition of bank material, and proximity to culvert outlets or inlets.

Vegetation Characteristics

Table 3.2 lists all dominant plant species noted on the data forms during the study area mapping effort. Species are identified by their common and scientific

Table 3.2. Dominant species noted during Emigration Creek mapping work.

SCIENTIFIC NAME	COMMON NAME	WETLAND INDICATOR STATUS	NATIVE TO UTAH OR INTRODUCED
Acer grandidentatum	bigtooth maple	obligate upland	native
Achillea millefolium	common yarrow	facultative upland	native
Acer negundo	box elder	facultative wetland	native
Aegilops cylindrica	jointed goatgrass	obligate upland	introduced
Ailanthus altissima	tree of heaven	no indicator	introduced
Ambrosia artemisiifolia	annual ragweed	facultative upland	native
Arctium minus	lesser burdock	obligate upland	introduced
Artemisia tridentata	big sagebrush	obligate upland	native
Bromus arvensis	field brome	obligate upland	introduced
Bromus inermis	smooth brome	obligate upland	introduced/naturalized
Bromus tectorum	cheatgrass	obligate upland	introduced
Catabrosa aquatica	water whorlgrass	obligate wetland	native
Cardaria draba	whitetop (hoary cress)	obligate upland	introduced
Campanula rapunculoides	rampion bellflower	obligate upland	introduced
Cichorium intybus	chicory	obligate upland	introduced
Convolvulus arvensis	field bindweed	obligate upland	introduced
Cornus sericea	redosier dogwood	facultative wetland	native
Crataegus spp.	hawthorn	obligate upland	unknown
Cynoglossum officinale	gypsyflower (houndstongue)	no occurrence	introduced
Elaeagnus angustifolia	Russian olive	facultative	introduced
Elymus repens	quackgrass	facultative upland	introduced
Euphorbia myrsinites	myrtle spurge	obligate upland	introduced
Fraxinus pennsylvanica	green ash	facultative wetland	native
Gleditsia triacanthos	honeylocust	facultative	native
Hedera helix	English ivy	obligate upland	introduced
Leymus cinereus	basin wildrye	no indicator	native
Lepidium latifolium	broadleaved pepperweed	facultative	introduced
Linaria dalmatica	dalmatian toadflax	obligate upland	introduced
Lonicera involucrata	twinberry honeysuckle	facultative	native
Maianthemum racemosum	feathery false lily of the valley	obligate upland	native
Mahonia repens	creeping barberry	obligate upland	native
Mentha arvensis	wild mint	facultative wetland	native
Melilotus officinalis	yellow sweetclover	facultative upland	introduced
Medicago sativa	alfalfa	obligate upland	introduced
Onopordum acanthium	scotch cottonthistle	obligate upland	introduced
Parthenocissus quinquefolia	Virginia creeper	no occurrence	native
Phalaris arundinacea	reed canarygrass	obligate wetland	native
Populus alba	white poplar	obligate upland	introduced
Populus angustifolia	narrowleaf cottonwood	facultative	native
Poa bulbosa	bulbous bluegrass	obligate upland	introduced
Populus deltoides	eastern cottonwood	facultative wetland	native
Populus fremontii	fremont cottonwood	facultative wetland	native
Poa pratensis	Kentucky bluegrass	facultative upland	introduced
Prunus virginiana	chokecherry	facultative upland	native
Pseudoroegneria spicata	bluebunch wheatgrass	obligate upland	native
Quercus gambelii	Gambel oak	obligate upland	native
Rhus trilobata	skunkbush sumac	no indicator	native
Rosa woodsii	Woods' rose	facultative	native
Rumex crispus	curly dock	facultative wetland	introduced

Table 3.2. Dominant species noted during Emigration Creek mapping work (cont.).

SCIENTIFIC NAME	COMMON NAME	WETLAND INDICATOR STATUS	NATIVE TO UTAH OR INTRODUCED
Salix exigua	narrowleaf willow	obligate wetland	native
Salix fragilis	crack willow	facultative	introduced
Secale cereale	cereal rye	obligate upland	introduced
Solanum dulcamara	climbing nightshade	facultative	introduced
Taraxacum officinale	common dandelion	facultative upland	introduced/ naturalized
Toxicodendron rydbergii	western poison ivy	facultative upland	native
Tribulus terrestris	puncture vine	obligate upland	introduced
Ulmus pumila	Siberian elm	obligate upland	introduced
Veronica americana	American speedwell	obligate wetland	native
Vinca major	bigleaf periwinkle	obligate upland	introduced
Vinca minor	common periwinkle	obligate upland	introduced

names, mapping code, wetland indicator status (USFWS 1988, USACE 2008), and whether the species is native to Utah or introduced (NRCS 2009). Sixty different species were noted during the Emigration Creek mapping work, about half of which are native to Utah. As seen in Table 3.3, most of the nonnative species within the corridor occur in the canopy and understory vegetation layers, while the shrub layer is dominated entirely by native species. Box elder (*Acer negundo*) and cottonwood (*Populus* sp.) are the most common trees along the stream-side areas of Emigration Creek, with Gambel oak (*Quercus gambelii*) common on undeveloped upper slope areas. Siberian elm (*Ulmus pumila*)and Russian olive (*Elaeagnus angustifolia*), which are introduced invasive trees, are also quite common in the study area (Table 3.3). Common shrub species include narrowleaf willow (*Salix exigua*), twinberry honeysuckle (*Lonicera involucrata*), and redosier dogwood (*Cornus sericea*), with Wood's rose (*Rosa woodsii*) common on upper portions of slopes. The understory vegetation layer shows the greatest species variety. Creeping barberry (*Mahonia repens*) is the most common native understory species in stream-side areas, with bluebunch wheatgrass and ragweed (*Ambrosia* sp.) common on upper slopes. Introduced ornamental English ivy (*Hedera helix*) and periwinkle (*Vinca* sp.) dominate the understory cover in a number of the urbanized residential stream reaches. Other common nonnative understory species include lesser burdock (*Arctium minus*) and climbing nightshade (*Solanum dulcamara*) (Table 3.3).

Canopy (tree) cover is generally high throughout the study area. All but ten of the mapped near-stream vegetation polygons have cover values greater than 75%. Because of the high-quality tree cover within the Emigration Creek riparian corridor, the riparian functions of shading and

Vegetation associations present in the study area:

- Big Sagebrush Shrubland / Introduced Herbaceous
- Bigtooth Maple / Narrowleaf Cottonwood / Redosier Dogwood Woodland
- Box Elder Forest
- Box Elder / Narrowleaf Cottonwood / Redosier Dogwood Forest
- Box Elder / Narrowleaf Willow Woodland
- Box Elder / Gambel Oak Woodland
- Box Elder / Disturbed Understory Woodland
- Box Elder / Redosier Dogwood Forest
- Box Elder Semi-natural Woodland
- Chokecherry Shrubland
- Eastern Cottonwood Semi-natural Woodland

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

PLANT SPECIES	Common Name	Scientific Name	UEM_R16	UEM_R17	LEM_R01	LEM_R02A	LEM_R02B	LEM_R02D	LEM_R03A	LEM_R03B	LEM_R04	LEM_R05A	LEM_R05B	LEM_R06	LEM_R07	LEM_R08A	LEM_R08B	LEM_R09A	LEM_R09B	LEM_R09C	LEM_R10	LEM_R11B	LEM_R13A
CANOPY	Bigtooth maple	*Acer grandidentatum*															X		X	X	X		
	Box elder	*Acer negundo*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Chokecherry	*Prunus virginiana*																X	X		X		
	Crack willow [a]	*Salix fragilis* [a]																X	X	X			
	Eastern cottonwood	*Populus deltoides*	X	X	X		X			X	X	X	X			X					X		X
	Fremont cottonwood	*Populus fremontii*														X	X		X				
	Gambel oak	*Quercus gambelii*								X	X	X	X			X	X	X	X	X	X		
	Green ash	*Fraxinus pennsylvanica*																		X			
	Hawthorn [a]	*Crataegus spp.* [a]								X	X												
	Honeylocust [a]	*Gleditsia triacanthos* [a]													X								
	Narrowleaf cottonwood	*Populus angustifolia*			X						X	X						X	X	X	X		X
	Russian olive [b]	*Elaeagnus angustifolia* [b]								X	X	X						X	X	X	X		
	Tree of Heaven [b]	*Ailanthus altissima* [b]																		X			
	Siberian elm [b]	*Ulmus pumila* [b]	X				X	X	X	X	X	X	X							X	X	X	X
	White poplar [a]	*Populus alba* [a]			X					X	X												
SHRUB	Big sagebrush	*Artemisia tridentata*																X					
	Narrowleaf willow	*Salix exigua*	X	X	X				X		X	X	X										
	Redosier dogwood	*Cornus sericea*			X	X	X			X	X	X	X					X	X	X	X		
	Skunkbush sumac	*Rhus trilobata*													X			X	X		X		
	Twinberry honeysuckle	*Lonicera involucrata*								X	X	X	X	X	X	X	X	X	X	X	X		
	Woods' rose	*Rosa woodsii*	X	X	X	X	X			X	X												X
UNDERSTORY	Alfalfa [a]	*Medicago sativa* [a]																		X			
	American speedwell	*Veronica americana*		X	X																		
	Annual ragweed	*Ambrosia artemisiifolia*								X								X	X	X	X		
	Basin wildrye	*Leymus cinereus*																		X			
	Bigleaf periwinkle [c]	*Vinca major* [c]													X						X		X
	Bluebunch wheatgrass	*Pseudoroegneria spicata*								X	X							X	X	X	X		
	Broadleaved pepperweed [b]	*Lepidium latifolium* [b]			X																		
	Bulbous bluegrass [a]	*Poa bulbosa* [a]								X					X								
	Cereal rye [a]	*Secale cereale* [a]																X			X		
	Cheatgrass [c]	*Bromus tectorum* [c]								X													
	Chicory [a]	*Cichorium intybus* [a]																		X			
	Climbing nightshade [a]	*Solanum dulcamara* [a]	X		X		X															X	

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

PLANT SPECIES			UEM_R16	UEM_R17	LEM_R01	LEM_R02A	LEM_R02B	LEM_R02D	LEM_R03A	LEM_R03B	LEM_R04	LEM_R05A	LEM_R05B	LEM_R06	LEM_R07	LEM_R08A	LEM_R08B	LEM_R09A	LEM_R09B	LEM_R09C	LEM_R10	LEM_R11B	LEM_R13A
	Common Name	Scientific Name																					
UNDERSTORY	Common periwinkle [c]	*Vinca minor* [c]				X										X	X						X
	Creeping barberry	*Mahonia repens*						X								X	X	X	X	X	X		X
	Curly dock [a]	*Rumex crispus* [a]																			X		
	Dalmatian toadflax [b]	*Linaria dalmatica* [b]																		X	X		
	English ivy [c]	*Hedera helix* [c]													X		X						X
	Feathery false lily of the valley	*Maianthemum racemosum*																		X	X		
	Field bindweed [b]	*Convolvulus arvensis* [b]																		X	X		
	Field brome [a]	*Bromus arvensis* [a]													X								
	Houndstongue [b]	*Cynoglossum officinale* [b]														X				X			
	Jointed goatgrass [b]	*Aegilops cylindrica* [b]																X		X	X		
	Kentucky bluegrass [a]	*Poa pratensis* [a]			X	X													X	X	X		
	Lesser burdock [b]	*Arctium minus* [b]			X	X	X	X								X	X			X	X		
	Myrtle spurge [b]	*Euphorbia myrsinites* [b]									X	X								X			
	Puncture vine [b]	*Tribulus terrestris* [b]																		X			
	Quackgrass [b]	*Elymus repens* [b]																		X			
	Rampion bellflower [c]	*Campanula rapunculoides* [c]														X	X						
	Reed canarygrass	*Phalaris arundinacea*	X																	X			
	Scotch cottonthistle [b]	*Onopordum acanthium* [b]																X		X	X		
	Smooth brome [a]	*Bromus inermis* [a]																			X		
	Virginia creeper	*Parthenocissus quinquefolia*				X																	
	Water whorlgrass	*Catabrosa aquatica*		X																			
	Western poison ivy	*Toxicodendron rydbergii*								X	X									X			
	Whitetop (hoary cress) [b]	*Cardaria draba* [b]																		X	X		
	Wild mint	*Mentha arvensis*			X																		
	Yellow sweetclover [a]	*Melilotus officinalis* [a]																		X			

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

water-temperature control are met to a high degree. In contrast, plant cover within the lower structural layers is typically much lower, with 31 and 28 of the mapped near-stream 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 near-

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
LEM_R02D	1	76–100+	6–25	1–5	moderate
LEM_R03A/R03B	2	76–100+	0	0	high
LEM_R03A	3	0	76–100+	0	none
LEM_R03B	4	76–100+	6–25	26–50	high
LEM_R03B	5	76–100+	0	76–100+	high
LEM_R03B/R04	6	76–100+	76–100+	26–50	moderate
LEM_R04	7	76–100+	6–25	0	none
LEM_R04	8	51–75	0	6–25	moderate
LEM_R04/R05A	9	51–75	0	6–25	moderate
LEM_R04	10	26–50	51–75	0	none
LEM_R04/R05A	11	76–100+	26–50	0	high
LEM_R05A	12	76–100+	26–50	0	high
LEM_R05B	13	76–100+	51–75	0	moderate
UEM_R16	14	76–100+	26–50	26–50	moderate
UEM_R17	15	51–75	26–50	6–25	none
UEM_R17	16	76–100+	26–50	6–25	low
LEM_R01	17	76–100+	26–50	26–50	moderate
LEM_R01	18	76–100+	51–75	26–50	moderate
LEM_R01	19	76–100+	26–50	26–50	high
LEM_R06	20	76–100+	6–25	0	none
LEM_R09A	21	76–100+	26–50	51–75	low
LEM_R09A/R09B	22	76–100+	26–50	51–75	low
LEM_R09C/R10	23	76–100+	26–50	51–75	low
LEM_R09C	24	76–100+	26–50	51–75	low
LEM_R09C	25	76–100+	26–50	51–75	low
LEM_R09A/R09B/R09C	26	76–100+	76–100+	0	moderate
LEM_R09C	27	76–100+	51–75	6–25	moderate
LEM_R10	28	76–100+	51–75	0	high
LEM_R10	29	76–100+	6–25	0	none
LEM_R13A	30	76–100+	6–25	6–25	moderate
LEM_R13A	31	76–100+	6–25	26–50	high
LEM_R02A	32	51–75	26–50	51–75	moderate
LEM_R02B	33	76–100+	26–50	6–25	moderate
LEM_R11B	34	76–100+	0	6–25	moderate
LEM_R08B	37	76–100+	6–25	51–75	majority
LEM_R08A	38	26–50	51–75	26–50	high
LEM_R08B	39	76–100+	26–50	51–75	majority
LEM_R08A	40	76–100+	26–50	51–75	majority
LEM_R07	41	6–25	6–25	76–100+	high
LEM_R07	42	51–75	6–25	76–100+	majority
LEM_R10	201	26–50	6–26	76–100+	majority
LEM_R10	202	76–100+	0	51–75	majority
LEM_R10	203	6–26	0	76–100+	high
LEM_R10	204	76–100+	0	51–75	majority
LEM_R09C	205	76–100+	0	26–50	majority
LEM_R09C	206	76–100+	0	76–100+	majority
LEM_R09C	207	6–26	0	76–100+	majority
LEM_R09C	208	76–100+	0	76–100+	majority
LEM_R09C	209	0	0	76–100+	majority

Table 3.4 Percent cover and invasive species class for mapped vegetation polygons (cont.).

REACH	POLYGON NUMBER	PERCENT CANOPY COVER	PERCENT SHRUB COVER	PERCENT UNDERSTORY COVER	INVASIVE SPECIES CLASS
LEM_R09C	210	76–100+	0	26–50	high
LEM_R09C	211	76–100+	6–25	76–100+	moderate
LEM_R09C/R09B/ R09A	212	0	0	76–100+	majority
LEM_R09A	213	0	6–25	76–100+	majority
LEM_R09B	214	76–100+	26–50	0	moderate
LEM_R09B	215	6–25	0	76–100+	none
LEM_R09B	216	76–100+	6–25	0	none
LEM_R09C	217	76–100+	6–25	6–25	moderate
LEM_R10	218	76–100+	6–25	51–75	high
LEM_R10	219	0	0	76–100+	majority
LEM_R10	220	26–50	6–25	76–100+	majority

stream 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). In reaches LEM_R09 and LEM_R10, the channel is surrounded by a wider area of natural upland vegetation. Polygons mapped in these upland areas farther away from the stream (polygons 201–220) generally included high amounts of invasive plants (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 Emigration Creek corridor. These issues are discussed by function below.

Aesthetics

Although many visually appealing portions of Emigration 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, ropes, tarps, etc. These items are common in the more accessible stream reaches that are used for recreation. Another common category of trash is remnant/obsolete infrastructure such as pieces of concrete and asphalt, old pipes and barrels, broken fencing, 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. Twenty-seven individual, significant litter areas were mapped in the study area during the RCS baseline assessment work.

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 Emigration 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 corridor connectivity, is the presence of stream-crossing culverts. Fourteen culvert crossings are present within the study area (Figure 3.11). Most 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 Emigration 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 1 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 a 3,200-foot-long segment between 1900 East and 1700 South, and study reach UEM_R16, which is 2,800 feet long (Figure 3.11).

Nutrient Filtration and Sediment Trapping

As discussed above, many areas of the Emigration 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 English 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 Emigration Creek riparian corridor. Specific issues are discussed in the subsections below.

Stream-Crossing Culverts

Localized erosion and deposition problems were noted at many of the stream-crossing culverts within the study area. Most of the culverts have diameters of 4–5.5 feet (Table 3.5), which is significantly smaller than the 17-foot average channel width at high flow. Because of this width

Vegetation associations present in the study area (cont.):

- Gambel Oak Forest
- Gambel Oak / Sparse Understory Shrubland
- Introduced Ornamental Semi-natural Woodland
- Introduced Herbaceous
- Mixed Semi-natural Woodland
- Mixed Semi-natural Trees and Shrubs / Introduced Herbaceous
- Mixed Semi-natural Woodland / Introduced Herbaceous
- Narrowleaf Cottonwood / Narrowleaf Willow Woodland
- Narrowleaf Willow Barren Shrubland
- Narrowleaf Cottonwood / Redosier Dogwood Woodland
- Russian Olive Semi-natural Woodland
- Siberian Elm / Russian Olive Introduced Ornamental Woodland
- Siberian Elm Semi-natural Woodland
- Siberian Elm Introduced Ornamental Woodland / Kentucky Bluegrass Introduced Herbaceous
- White Poplar Semi-natural Woodland

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

CROSSING LOCATION AND DESCRIPTION	REACH NUMBER(S)	CULVERT LENGTH (ft) [a]	VERTICAL DROP FROM INLET TO OUTLET [b] (ft) [a]	CULVERT TYPE	CULVERT DIAMETER (ft) [a]	INLET CONDITION	OUTLET CONDITION
Emigration Canyon	between UEM_R16 and UEM_R17	1029	53	round concrete pipe	4	not assessed	fair; crack in concrete headwall; obsolete silt fence; rock outlet protection functioning well
Debris Basin Outlet	LEM_R01	187	3	round pipe	4.6	not assessed	fair; partially filled with silt
Crestview Drive	between LEM_R01 and LEM_R02A	242	9	round corrugated metal pipe	5.5	good	poor; bank erosion; 4-5 ft. scour depth
Hogle Zoo	between LEM_R02A and LEM_R02B	1174	57	round corrugated metal pipe	5.5	good	poor; scour around concrete apron (2.8' depth); trash/concrete chunks
Path in middle of LEM_R02D	LEM_R02D	51	<1	metal three-sided arch	8.5 H x 13.5 W [c]	good	good
Bonneville Golf Course-eastern golf path crossing	between LEM_R02D and LEM_R03A	181	8	round concrete pipe	5	good; some debris at grate	poor; scour around concrete apron (2.5' depth); rebar/concrete chunks
Bonneville Golf Course-central golf path crossing	between LEM_R03A and LEM_R03B	85	5	round concrete pipe	5	poor: significant debris and sediment accumulation	poor; scour around concrete apron (3' depth); steep/bare banks
Bonneville Golf Course-western golf path crossing	between LEM_R05A and LEM_R05B	73	6	round concrete pipe	5	poor; debris jam diverting flow; tree leaning on headwall	poor; crack in concrete headwall; scour/undercutting around apron; bare slopes
Foothill Drive	between LEM_R05B and LEM_R06	223	2	round concrete pipe	5	fair; some debris accumulation and erosion around concrete wing wall	fair; tailwater pool present; steep/bare banks; some bank erosion
2100 East	between LEM_R06 and LEM_R07	280	20	concrete box (inlet); round concrete pipe (outlet)	3 H x 4 W (inlet) [c]; 4.75 (outlet)	fair; some trash/ sediment deposition at grate	poor; severe bank erosion; scour around concrete apron; broken concrete wall
1300 South	between LEM_R07 and LEM_R08A	200	6	round concrete pipe	4	fair; some concrete chunks and minor erosion around grouted rock headwall	fair; large concrete apron and concrete walls; some erosion at lip of apron and at edge of headwall
1900 East	between LEM_R08B and LEM_R09A	358	10	round concrete pipe	4	fair; appears to clog occasionally;	good; tailwater pool present
1700 South	between LEM_R10 and LEM_R11A	559	35	two vertically stacked concrete boxes	each 3 H x 3 W [c]	poor; appears to clog regularly and cause silt deposition for ~200 ft upstream	not assessed
1500 East	between LEM_R11B and LEM_R12	499	12	square concrete pipe	3 H x 3W [c]	fair; clogs periodically; asphalt and concrete chunks around/ above headwall	not assessed
1300 East	between LEM_R12 and LEM_R13A	361	13	round concrete pipe	3.8	not assessed	poor; bed, and bank erosion evident; scour around broken concrete apron; rill at storm outfall

[a] Feet.
[b] Elevation change between inlet and outlet based on digital elevation data.
[c] H = height, W = width.

Invasive plants of concern in the study area:

- Russian olive
- Siberian elm
- lesser burdock
- cheatgrass
- myrtle spurge
- periwinkle vine
- English ivy
- broadleaved pepperweed
- whitetop
- dalmatian toadflax
- houndstongue
- quackgrass
- puncture vine
- Scotch thistle
- tree of heaven
- rampion bellflower
- jointed goatgrass
- field bindweed

discrepancy, a hydraulic constriction occurs at culvert inlets, slowing flow velocities and leading to deposition and accumulation of sediment and debris. During the springtime high-flow period, regular maintenance is needed to keep culvert inlets from becoming blocked by debris and creating a stability and flooding concern. In between maintenance visits, inlets often become partially clogged, creating backwater pools and causing silt to drop out onto the affected streambanks. This silt buries existing plants and limits future vegetation establishment, leaving bare bank areas that are susceptible to erosion during storm events.

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

The size and design of the stream-crossing culverts also contribute to stability concerns at the culvert outlets. During high flows velocities at the culvert outlets are very high because of width constriction and a lack of bed roughness within the smooth concrete pipe material. Most of the culverts have wingwalls and aprons made of concrete, which further accelerates velocities. This leads to scour and bank erosion where the outlet structure meets the natural channel and banks. Scour holes between 2.5–5.0 feet deep were measured at culvert outlets within the study area.

The stream-crossing culverts on Emigration Creek create significant interruptions in the transport of sediment and woody debris through the corridor. Because they create "hard points" in the streambed, they also control and alter local stream gradient and affect

Factors limiting shrub and understory cover:

- oversteepened slopes
- inadequate revegetation efforts following construction
- soil compaction from heavy foot traffic
- bank siltation at culvert inlets
- uncontrolled runoff from upland areas

channel characteristics. Within a given stream reach bounded by culverts, there is commonly an upstream "zone" near the culvert outlet that is characterized by scour and evidence of streambed lowering and a downstream zone near the culvert inlet that is flatter and shows evidence of sediment deposition. The length of these culvert-influenced zones varies, but it can be as great as 200 feet in some reaches.

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 Emigration Creek channel, and evidence of rill erosion in these areas is common. Of the 23 mapped outfall locations, 16 were ranked as medium- or high-priority areas for stability improvements.

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. Several RCS workshop attendees described bank erosion problems on their property that began after fill-placement or bank-hardening projects on adjacent properties altered streamflow patterns. 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.

Below: (left) Terrace erosion; (right) Low bank/root zone erosion.