VOLUME 1 - REPORT

SOUTHWEST CANAL AND CREEK STUDY

PHASE 2 - MIDAS CREEK

Prepared for:

SALT LAKE COUNTY

September 2021

Prepared by:

BOWEN COLLINS & ASSOCIATES

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CHAPTER 1
INTRODUCTION

BACKGROUND INFORMATION

The original Southwest Canal and Creek Study (SWCCS) was completed in 2002 (2002 SWCCS). The primary purpose of the 2002 SWCCS was to identify institutional and structural improvements needed to manage storm water runoff conveyed in the creeks and canals located in the southwest quadrant of Salt Lake County in a cost-effective, efficient manner. Since the 2002 SWCCS was completed, the combined population of Herriman, Riverton, and South Jordan Cities has increased from about 56,000 to 154,000, and significant changes have been made to some of the critical planning and development assumptions used in completing that study. Because of those changes, the County is updating the 2002 SWCCS. The County retained BC&A to update the Southwest Canal and Creek Study.

The SWCCS is being updated in phases and will eventually include all creeks and canals studied in the 2002 SWCCS. This report has been developed for the second phase of the updated SWCCS, which includes a capacity evaluation of Butterfield Creek and Midas Creek considering recent and planned development, and identifying needed improvements to the creeks to safely manage storm water. Additional analyses and reports of the other creeks from in the southwest quadrant of Salt Lake County will be completed in the future.

STUDY AREA

The study area for this project is shown on Figure 1-1.

MIDAS CREEK

Midas Creek is an ephemeral stream that only flows in response to storm events. Runoff collects upstream of Bacchus Hwy (U111) and is conveyed along a well-defined channel to the Jordan River at approximately 11200 South. Midas Creek also receives runoff from two ephemeral tributaries: Butterfield Creek and Copper Creek. Additional explanations of Butterfield Creek and Copper Creek are in subsequent sections or this report. Midas Creek is the major outfall for storm water runoff from portions of Herriman City, Riverton City and South Jordan City.

BUTTERFIELD CREEK

Butterfield Creek is also an ephemeral tributary to Midas Creek that only flows in response to storm events. It collects runoff from Butterfield Canyon. The drainage area of Butterfield Creek at the confluence of Midas Creek is 12.3 square miles. Prior to the 1990s, Butterfield Creek was a separate channel from Midas Creek with its own outfall to the Jordan River. During the 1990s, Butterfield Creek was re-routed to Midas Creek with the new confluence at approximately 4800 West.

In 2007, a pipeline was constructed to enclose the reach of Butterfield Creek between approximately 12800 South 6300 West and approximately 12100 South 5400 West, as shown in Figure 1-2. Salt Lake County owns and maintains that reach of pipeline.

Upstream of 6300 West, there is currently significant development in the Butterfield Creek drainage basin between approximately 6700 West and 7000 West. As part of that development, channel improvements and culvert improvements are being made to Butterfield Creek. The project has not been completed as of November 2020, but it is anticipated that this segment of Butterfield Creek will be completed within the few years.

COPPER CREEK

Copper Creek is a small ephemeral wash between Midas Creek and Butterfield Creek. Most of the land in the Copper Creek drainage area west of 6400 West is dry farmed. Much of the natural Copper Creek drainage channel between Bacchus Highway and 6000 West has been filled in and farmed over. Prior to 2018, runoff in the Copper Creek drainage area was conveyed through a large drainage swale to Herriman Parkway at 6000 West. There, it discharged into an intake structure and joined Butterfield Creek in the 60-inch RCP to be conveyed to Midas Creek, as shown on Figure 1-2.

Construction on a channel was completed in 2018 at approximately 6600 West that re-routed runoff from the Copper Creek drainage area and conveyed it directly to Midas Creek at approximately 6500 West, as shown on Figure 1-2. The drainage area for Copper Creek after the channel was construction at the confluence of Midas Creek and Copper Creek is 1.8 square miles. Copper Creek has its own drainage master plan and was not included in the 2002 SWCCS, a detailed analysis of Copper Creek was not included in the SWCCS.

RIO TINTO MINING OPERATIONS

Prior to 2013, the collection facilities for storm water runoff from the waste rock along the east side of the Bingham Open Pit Mine, owned by the Rio Tinto Corporation, were sized for the 10-percent-annual-chance-flood (10-year flood). Runoff from the 1-percent-annual-chance-flood (100-year flood) would by-pass those collection facilities and discharge to Midas Creek, Butterfield Creek, or Copper Creek. The 2002 SWCC study analyzed the 100-year event and assumed that runoff from the waste rock along the east side of Bingham Open Pit Mine flowed into Midas Creek or Butterfield Creek, respectively.

Over the past 7 years, the capacity of those drainage facilities has been increased to collect and convey runoff from the 100-year event. As a result, the drainage areas included in the model for Midas Creek and Butterfield Creek have decreased significantly compared to the 2002 SWCCS. The removed drainage area is identified on Figure 1-1.

PURPOSE OF STUDY

The primary purpose of this study is to identify improvements needed to manage storm water runoff that is conveyed in Midas Creek and Butterfield Creek.

MAJOR STUDY TASKS

BC&A performed the following major tasks in completing this study:

- Developed a Hydrologic Model of Midas and Butterfield Creeks
- Developed a Hydraulic Model of Midas and Butterfield Creeks
- Evaluated Alternatives to Limit Discharge to Midas and Butterfield Creeks
- Reviewed Alternatives with Stakeholders
- Recommended Improvements Based on Input from Stakeholders
- Prepared this Report.

The results of the work associated with completing these tasks are presented in this report. Questions associated with this report may be addressed to Kameron Ballentine P.E., who served as the project engineer or Craig Bagley P.E., CFM, who served as project manager.

CHAPTER 2
REVIEW OF EXISTING CONDITIONS

Several sources of data regarding the existing development and hydrologic conditions of the Midas Creek and Butterfield Creek drainage basins were collected and analyzed as part of this project. Some of those data sets included topographic information, field survey of bridges and culverts, and field reconnaissance observations. A visual assessment of the general conditions of the study reach of the creek was also completed. The purpose of this chapter is to summarize the general existing conditions that currently exist in the Midas Creek and Butterfield Creek drainage areas and to summarize what other data was collected, reviewed and used to perform the technical analyses.

DATA COLLECTION

This section discusses the data collection and analyses associated with topography, survey, and field reconnaissance. The primary goals of this task were to compile a detailed inventory of the structures on Midas Creek and Butterfield Creek, and to collect information needed to develop hydraulic models of these creeks.

Topography and Aerial Photography

Topographic and aerial photographic mapping along Midas Creek and Butterfield Creek were collected from the Utah Automated Geographic Reference Center (AGRC). The aerial photography was the 2018 High Resolution Imagery, and the topography is the bare earth LiDAR data from 2013-14 with 0.5-foot contours. The aerial photographs were used for the backgrounds on most of the figures used in this report.

Field Survey

Channel cross sections of the study reaches of Midas Creek and Butterfield Creek were field surveyed at about 500-foot intervals through the open channel sections of the creeks. Because Midas and Butterfield Creeks are ephemeral, the survey took place when the creeks were not flowing. Survey data was also collected for three canal dump-out structures that discharge storm water into Midas Creek where the Utah Lake Distributing Canal, Utah and Salt Lake Canal, and South Jordan Canal cross the creek.

INVENTORY OF STRUCTURES

This section presents an inventory of the existing structures along the study reaches of Midas Creek and Butterfield Creek. The inventory of structures is summarized on Figure 2-1 and Figure 2-2.

Bridges & Culverts & Drop Structure

There are 13 culverts or pipelines on Butterfield Creek and 41 bridges or culverts on Midas Creek. Each of the structures are identified on Figure 2-1 and Figure 2-2. Field survey or each structure was collected and used to develop the hydraulic models as described in Chapter 5.

Dump-out Structures

There are three storm water overflow/dump-out structures that allow storm water discharged into canal to be discharged into Midas Creek. The overflow structures include a gate to manually drain the canal and a weir to allow for an automatic overflow of storm water into the creek, as shown on Photo 2-1. Table 2-1 identifies the locations of the 3 existing storm drain overflow/dump-out structures. There are no canal dump-out structures on Butterfield Creek.

Table 2-1
Existing Storm Drain Overflow/Dump-Out Structures

Canal Crossing	Approximate Storm Drain Overflow Structure Location
Utah Lake Distributing Canal	3300 West
Utah and Salt Lake Canal	2400 West
South Jordan Canal	1500 West

The Welby Jacob Canal does not have a dump-out structure at Midas Creek because it does not currently accept any urban runoff due to its limited capacity.

Photo 2-1 Overflow/Dump-Out Structure Where South Jordan Canal Crosses Midas Creek

SUMMARY OF GENERAL OBSERVED RISKS

A visual assessment of Midas Creek and Butterfield Creek was completed. The purpose of the visual assessment was to observe general conditions of the creeks and identify potential hazards, issues and concerns. This section summarizes the observations noted during the visual assessment. Observed issues and concerns are identified on Figure 2-1 and Figure 2-2.

General Observed Risks

The visual assessment took place in early 2020. The following potential issues and concerns were observed along the Midas Creek Channel.

- Fences that cross the channel

- Uncertifiable levees
- Trash Racks
- Potential unpermitted culverts
- Eroded channel banks
- Use of non-angular (rounded) riprap for channel armoring
- Poorly Defined Channel

Each of those potential issues and concerns are discussed below.

Fences that Cross the Channel. There are several locations where fences cross the Midas Creek Channel. During a large flood it is likely that debris would collect on the fences and restrict flow through the channel. Some of the locations of those fence crossings are identified in Appendix A.

Uncertified Levees. There is an uncertified levee adjacent to a subdivision between 2700 West and the Utah and Salt Lake Canal. FEMA is in the process of updating the Flood Insurance Rates Maps (FIRMs) between 2700 West and the Utah and Salt Lake Canal. The preliminary FIRMs identify an area behind the uncertified levee, which includes multiple new homes, as a Zone AE special flood hazard area. This designation requires that homeowners purchase flood insurance. The preliminary FIRMs are included in Appendix B. Photo 2-2 shows a portion of the uncertified levee.

Photo 2-2 Portion of Uncertified Levee on Midas Creek Between 2700 West and the Utah and Salt Lake Canal

Potential Unpermitted Culvert. There are is a small culvert immediately upstream of Eureka Way (2150 West), that was likely constructed without getting needed permits from the City, Salt Lake County, and the State of Utah. The culvert restricts the flow in the channel. However, the resulting floodplain in the vicinity of the unpermitted culvert appears to be confined within the channel banks and does not appear to impact an insurable structure.

Eroded Banks. The banks of Midas Creek in some areas have experienced significant erosion. The eroded banks and the associated bank instability in those areas are not currently adjacent to urban development and are not currently a major concern. Photo 2-3 identifies an area of bank erosion upstream of Bangerter Hwy.

Photo 2-3 Bank Erosion Upstream of Bangerter Highway

Rounded Riprap. There are several stream segments along Midas Creek where rounded riprap has been installed to armor the banks of Midas Creek. Riprap channel armoring should be angular so that it can better lock together to provide the required erosion protection. The rounded riprap is more likely to fail during a major runoff event.

Channel Encroachment of Butterfield Creek. There is a section of Butterfield Creek upstream of the Hidden Oaks Development Property (identified on Figure 2-2) at approximately 8000 West that is undersized for the 100-year event. The channel has been encroached by the farming activities to the north. During large runoff events, the runoff will likely spill out of the existing channel and flow across the farm field to the north. The potential for significant flood damage in this area is probably not a major problem today, but in the future when the area develops, the Butterfield Channel will need to be improved so it can safely convey the 100-year discharge.

Photo 2-4 Butterfield Creek Channel that has been encroached by Farming Activities

CHAPTER 3
PREVIOUS STORM DRAINAGE STUDIES

Data from previously published reports and studies were used to supplement information collected as part of this study. In the development of the hydrologic and hydraulic models for the SWCCS, previous studies were reviewed, and data from those existing studies were incorporated into the analysis. Table 3-1 is a summary of previously completed storm drainage studies that were referenced as part of this study.

Table 3-1
Previously Completed Drainage Studies SWCCS Area

Drainage Study	Date Completed	Prepared for	Prepared by	Study Area
Herriman City Storm Drain Master Plan	September 2020	Herriman City	Bowen Collins and Associates	Herriman City
Phase 1 of the SWCCS	March 2020	Salt Lake County	Bowen Collins and Associates	Rose Creek
Preliminary FEMA Floodplain Maps and Models	November 2017	Salt Lake County Flood Control	AECOM	Midas Creek
Copper Creek Drainage Master Plan	December 2014	Salt Lake County	CH2MHill	Copper Creek
South Jordan Storm Drain Master Plan	January 2011	South Jordan City	Franson Engineers	South Jordan City
UDOT Drainage Design Drawings for Mountain View Corridor	Sept 2010	UDOT	UDOT	Herriman and Riverton
Riverton City Storm Drain Master Plan Update	July 2010	Riverton City	Bowen Collins and Associates	Riverton City
Southwest Canal and Creek Study (2002)	April 2003	Salt Lake County Flood Control	Bowen Collins and Associates	SWCC Study Area

CHAPTER 4
HYDROLOGIC ANALYSIS

A hydrologic computer model of the Midas Creek drainage area was developed using the Autodesk Storm and Sanitary Analysis (ASSA) computer software. The model was used to estimate storm water runoff volumes and peak discharges generated by a design storm event and to route runoff to Midas Creek and Butterfield Creek for both the existing and full build-out conditions. This chapter focuses on the process and assumptions used to develop the hydrologic model for the study area. The methods used to estimate the hydraulic capacity of Midas Creek and Butterfield Creek and their related hydraulic structures is discussed in Chapter 5.

PREVIOUS MODELS

An ASSA model was developed for the Rose Creek Drainage area as part of phase 1 of the SWCCS. To be consistent, the same hydrologic modeling software was used for phase 2 (this study). The ASSA software utilizes the same procedures and routines to simulate the rainfall-runoff process as those used by the HEC-HMS software.

The methodology used to develop the hydrologic model parameters was the same as the original 2002 SWCCS and the Herriman City Storm Drain Master Plan. The process used to develop the hydrologic model is outlined in the following general steps, with detailed information on each step provided below:

1. Delineate Drainage Basins
2. Develop Hydrologic Modeling Parameters
3. Develop Design Storm Parameters
4. Calibrate Hydrologic Model.

DRAINAGE BASIN AND SUBBASIN DELINEATION

The Midas and Butterfield Creek drainage basin boundaries and related subbasin boundaries were delineated based on storm drain GIS inventory data provided by Riverton City, South Jordan City and Herriman City in conjunction with topographic data. The topographic data used for this study was developed using LiDAR data collected in 2013-2014 available on the Utah Automatic Geographic Resource Center (AGRC) website. Aerial photographs taken in 2018 and published by Google were also used to develop the subbasins and estimate the amount of directly-connected impervious area (which includes roads, curb and gutter, driveways, parking lots, roof tops, etc.) in each subbasin. The Midas Creek and Butterfield Creek drainage basin and subbasin boundaries developed as part of this study are shown on Figure 4-1.

HYDROLOGIC MODEL PARAMETERS

ASSA uses the United States Army Corps of Engineers HEC-HMS hydrologic engine based on SCS Curve Number methodology to compute runoff for each subbasin. This method requires lag time, CN value, percent impervious, and area for each subbasin as hydrologic input parameters. A description of each of these items is included below. The hydrologic model parameters are summarized in Appendix C.

Curve Number

The Curve Number (CN) was estimated for the pervious portion of the each subbasin based on soil type and vegetative ground cover. The Curve Numbers used in this study do not account for impervious land cover, like pavement. The methodology used in this study accounted for directly-connected impervious area by inputting that value in the model as a percentage of the area of each drainage subbasin. Using this approach is necessary for Salt Lake Valley's climate and geology, as peak runoff values from the 3-hour design storm would be severely underestimated for areas with Hydrologic Soil Groups (HSG) A and B soils when a "composite" curve number is used instead of entering impervious cover separately. The hydrologic soil type was obtained from the NRCS Soil Survey Geographic (SSURGO) dataset. The vegetative cover data for undeveloped land was obtained from the USGS National Land Cover Database (NLCD). Table 4-1 shows the Curve Numbers used in this study based on soil type and assumed ground cover. The soil types are identified on Figure 4-2 and NLCD are identified on Figure 4-3.

Table 4-1
SCS Curve Number

NLCD Number	NLCD Name	Equivalent Land Type Based on TR-55 Manual	CN Value for Hydrologic Soil Type[1]			
			A	B	C	D
11	Open Water	Water	98	98	98	98
12	Perennial Ice/Snow	Water	98	98	98	98
21	Developed Open Space	Open Space (Fair)	49	69	79	80
22	Developed Low Intensity	2 Acres	46	65	77	82
23	Developed Medium Intensity	1 acre	51	68	79	84
24	Developed High Intensity	1/4 acre	61	75	83	87
31	Barren Land	Bare Soil	77	86	91	94
41	Deciduous Forest	Oak-Aspen (Fair)	-	48	57	63
42	Evergreen Forest	Oak-Aspen (Fair)	-	48	57	63
43	Mixed Forest	Oak-Aspen (Fair)	-	48	57	63
51	Dwarf Scrub	Sagebrush (Fair)	-	51	63	70
52	Shrub/Scrub	Oak-Aspen (Fair)	-	48	57	63
71	Grassland/Herbaceous	Sagebrush (Fair)	-	51	63	70
72	Sedge/Herbaceous	Sagebrush (Fair)	-	51	63	70
73	Lichens	Bare Soil	77	86	91	94
74	Moss	Sagebrush (Fair)	-	51	63	70
81	Pasture/Hay	Sagebrush (Fair)	-	51	63	70
82	Cultivated Crops	Sagebrush (Fair to Good)	-	48	59	66
90	Woody Wetlands	Oak-Aspen (Fair)	-	48	57	63
95	Emergent Herbaceous Wetlands	Oak-Aspen (Fair)	-	48	57	63

[1] CN values were adjusted during the calibration process. The values shown in Table 4-1 are from Tables 2-2 in the TR-55 Manual and represent the final CN values used in the model.

Drainage and Subbasin Areas

Subbasin areas were calculated using computerized GIS technology and the delineated subbasin boundaries.

Directly-Connected Impervious Area

The amount of directly-connected impervious area for existing development conditions was estimated for each subbasin using the 2018 Google aerial photographs in conjunction with land use and zoning data provided by Salt Lake County, Herriman City, Riverton City, and South Jordan City. Each land use type was analyzed based on the aerial photography and the estimated impervious area was recorded. Table 4-2 identifies the percentage of directly-connected impervious area associated with various land uses or zoning for both existing and projected future build-out conditions. The amount of directly-connected impervious area was estimated for full build-out conditions based on projected land-use conditions from the General Plan for each City. For areas that are currently undeveloped, the General Plan for each city was used in conjunction with the data in Table 4-2 to estimate the amount of directly-connected impervious area. Figure 4-4 and Figure 4-5 identify the existing land use and future land use for this study.

Table 4-2
Average Percentage of Directly-Connected Impervious Area Based on Land Use

General Plan Land Use Type	Percent Directly-Connected Impervious Area (Percent)
Medium Density Residential 4-16 units/ac	35%
Low Density Residential 0-3 units/ac	15%
Low Density Residential 2-4 units/ac	20%
Church	75%
Medium Density Residential 4-16 units/ac	35%
Open Space	0%
Industrial	72%
Business/Commercial	85%
Road	100%
High Density Residential 16+ units/ac	70%

Lag Time

Lag time was calculated for mountain watersheds differently than urbanized watersheds. Lag times for urbanized subbasins were estimated using the Worksheet 3 from the TR-55 manual. Lag times for mountain watersheds were estimated using a rain-on-grid model in HEC-RAS. The inputs for the rain-on-grid model was the 2013-14 LiDAR data and the same design storm as the hydrologic model. The cell size ranged from 50 to 100 feet, and the roughness value was 0.06. The results of the rain-on-grid model are consistent with the Watershed Lag Time equation described in NEH 630.1502(a) manual, based on previous studies. Lag times used in the hydrologic model are included in Appendix C.

DESIGN STORM PARAMETERS

The design storm used for the analysis of Midas Creek was the same design storm used in Phase 1 of the SWCCS for Rose Creek Study, 2002 SWCCS and the Herriman Storm Drain Master Plan: a 100-year, 3-hour storm. This storm was selected because most flooding events in urbanized areas occur as a result of short cloudburst storm. This design storm was selected by the County and is the design standard that will be used to identify deficiencies and to size needed capacity improvements.

A design storm has a specified depth and temporal precipitation distribution. The design storm was applied to the entire study area using the "nested" Farmer-Fletcher temporal distribution. This distribution is a typical standard for most municipalities along the Wasatch Front.

The following parameters were used to develop the synthetic design storm.

- Storm Duration: 3 hours
- Temporal Precipitation Distribution: Modified Farmer-Fletcher
- Storm Recurrence Interval: 100-year
- Design Storm Depth (From NOAA Atlas 14): (100-Year) 1.92 inches

Areal Reduction of Precipitation Depth

Intense summer cloudburst events typically move across the Salt Lake Valley and rarely cover a large area. Precipitation depth reduction factors for the larger drainage basins were utilized in the hydrologic analysis to adjust point precipitation values for large areas. The NOAA Atlas 2 (1973) recommends a storm-centered areal reduction of 0 to 15 percent for 3-hour storm cells ranging from 0 to 100 square miles in area.

The NOAA precipitation depth adjustment factors, however, are based on data from thunderstorms in the Midwest, rather than those typical to the Salt Lake Valley. The results of a more locally pertinent depth-area precipitation analysis were taken from the Salt Lake City Hydrology Manual. That report recommends the following precipitation depth-area relationship for a thunderstorm of 3-hour duration, with area in square miles:

$$\text{Reduction Factor} = 0.01*(100 - 4.5*\text{Area}^{0.46})$$

The equation above is based on data from *Project Cloudburst,* a study completed by the U.S. Army Corps of Engineers in April 1979 and was used for this analysis. That study involved collection of data from a network of rain gages in Salt Lake City and the vicinity covering an area of roughly 350 square miles. The ARF for this study area consistent with the previous SWCCS and other studies in the area.

The precipitation depth-area relationship was used to estimate areal reduction factors for Midas Creek. Table 4-3 shows the areal reduction factors used for the project. The storm areas used to arrive at these reduction factors were estimated by constructing elliptical thunderstorm cells covering the drainage area contributing to each concentration point. The thunderstorm cell area was used in estimating the ARFs, in the equation listed above. The resulting reduction factors were rounded up to the nearest tenth of an inch, with a threshold reduction of 30 percent (reduction factor = 0.7). The estimated storm cell areas for existing and proposed conditions were the same.

The Areal Reduction factor for Midas Creek downstream of the Confluences of Butterfield Creek is 0.7. Upstream of that point for both Butterfield Creek and Midas Creek, no Areal Reduction Factor was used.

EXISTING DETENTION BASINS

The eastern portion of the Midas Creek drainage area is largely developed and includes multiple regional and local storm water detention facilities. Municipalities provided as-built drawings or design reports for the existing regional detention facilities. For smaller detention basins or where as-built drawings or design reports were not available, the general assumption was made that detention basins stored enough water to limit the peak design storm discharge to 0.2 cfs/acre, the rate that has been required historically by City and County ordinances for developed land in the study area.

MODEL CALIBRATION

The final step in the hydrologic modeling process was model calibration. In general, calibration of a hydrologic model refers to the process of adjusting model parameters to achieve results consistent with available reference information in nearby areas. Although Salt Lake County has operated a stream gage on Midas Creek just upstream of its confluence with the Jordan River since 2014, there is not enough or adequate flow data on Midas Creek or the City's urban drainage systems that could be used for model calibration. In addition, there are no other stream gages on the west side of the Salt Lake Valley.

Model Calibration on Ungaged Streams

The challenge with utilizing a rainfall-runoff model in an ungaged watershed like that of Midas Creek is determining how to calibrate the model or determining if the model results are reasonable or accurate. FEMA has published Guidelines and Specifications for how to perform a hydrologic study in an ungaged watershed. FEMA stipulates that on streams with limited or no stream gage data, runoff estimates should be computed using regional regression equations that are based on actual stream gage records. If no reliable regression equations are available, a computerized hydrologic model of an ungaged watershed can be used to estimate runoff for a design storm event. The 2002 SWCCS calibrated the hydrologic model to that peak discharges from the design storm were consistent with values for seven nearby gaged watersheds on the east side of the Jordan River. The 2002 SWCCS peak discharges were also consistent with the regional regression equations published by the USGS. For this study, the hydrologic model was calibrated to approximately match discharge estimates from the current regression equation analysis (published in 2008) performed by the USGS. This issue is discussed in more detail below.

Regional Regression Equations

USGS regional regression equations were used in the calibration process for this study. The USGS regional regression equations have been developed to estimate peak runoff values for discharges with specified return intervals in natural, undeveloped areas on ungaged streams. When using a regression equation to estimate a peak discharge associated with a specific return interval, one of the required input parameters is the total drainage area at the point on the channel where the discharge value is desired to be computed. One of the key locations in the area where a 100-year discharge estimate was desired was where Midas Creek crosses under 6000 West. This location was selected because it is upstream of most development and most of the watershed upstream of this point is undeveloped land.

USGS StreamStats

The USGS StreamStats online computer program is the current standard for estimating peak flow rates on ungaged streams and rivers. The USGS regression equation associated with estimating the magnitude of a 100-year flood in the Midas Creek drainage area is:

$$\text{PK100} = 6.92\ \text{DRNAREA}^{0.613}\ 1.06^{\text{PRECIP}}$$

Where: PK100 = peak discharge associated with the 100-year flood

DRNAREA = drainage area associate with a point in the watershed (in square miles)

PRECIP = mean annual precipitation of the drainage basin (in inches).

StreamStats has some online GIS applications integral with the program that were used to estimate key physical and hydrologic drainage basin parameters and runoff values for the watershed that is tributary to the Midas Creek crossing at 6000 West. Detailed input and output data for this analysis is included in Appendix D. The results of the analysis are summarized in Table 4-3.

Table 4-3
Summary of StreamStats Analysis for Midas Creek Crossing at 6000 West

Description	Value
Drainage Area	5.57 Square Miles
Mean Basin Elevation	5460 Feet
Basin-wide Mean Annual Precipitation	17.7 Inches
Range of Acceptable Drainage Areas	Min: 2.14 Square Miles – Max: 84.1 Square Miles
Range of Acceptable Annual Precipitation Depths	Min: 16.5 Inches – Max: 53.7 inches
Peak 100-year Discharge	52.9 cfs
Average Unit Discharge	0.015 cfs/ac
Standard Deviation	50%
Upper Confidence Limit	79.4 cfs
Lower Confidence Limit	26.4 cfs

As can be seen from Table 4-3, the drainage area and mean annual precipitation depth at 6000 West on Midas Creek are within the acceptable range of values to allow use of the USGS StreamStats equation. The peak 100-year discharge of 52.9 cfs results in a unit discharge or 0.015 cfs/acre with average standard error of about 50 percent. The upper confidence limit flow rate would be 79.4 cfs for the 100-year peak discharge, with a unit discharge rate of 0.022 cfs/ac.

Model Results

The model results were compared to the StreamStats and estimated flow rates and are identified in Table 4-4.

Table 4-4
Summary of Runoff Values for Midas Creek Crossing at 6000 West (cfs)

Runoff Computation Method	Average Runoff	Upper Confidence Limit	Lower Confidence Limit	ASSA Model Peak Runoff Estimate
StreamStats	52.9	79.4	26.4	-
ASSA Model	-	-	-	79.2

As can be seen from Table 4-4, the results from the model are within the confidence limits of the StreamStats equation. The model was calibrated by adjusting the CN values in the undeveloped subbasins until the design storm peak discharge rates were within the range of values of the StreamStats equation. The adjusted CN values used in the model were identified Table 4-1. The estimated peak runoff rate from the ASSA model at 6000 West was estimated to be 0.02 cfs/acre (79.2 cfs from 5.57 sq miles). That estimate is on the high end of the confidence limits from the StreamStats equation and was considered to be reasonable.

Historic Aerial Photos

As part of the calibration process, historic aerial photographs of upper portions of the Midas Creek and Butterfield Creek drainage areas were also reviewed. Below is a 1940 aerial photograph of the Butterfield and Midas Creek area that shows that well-defined channels did not exist at that time and that portions of the ephemeral channel were filled in and farmed over.

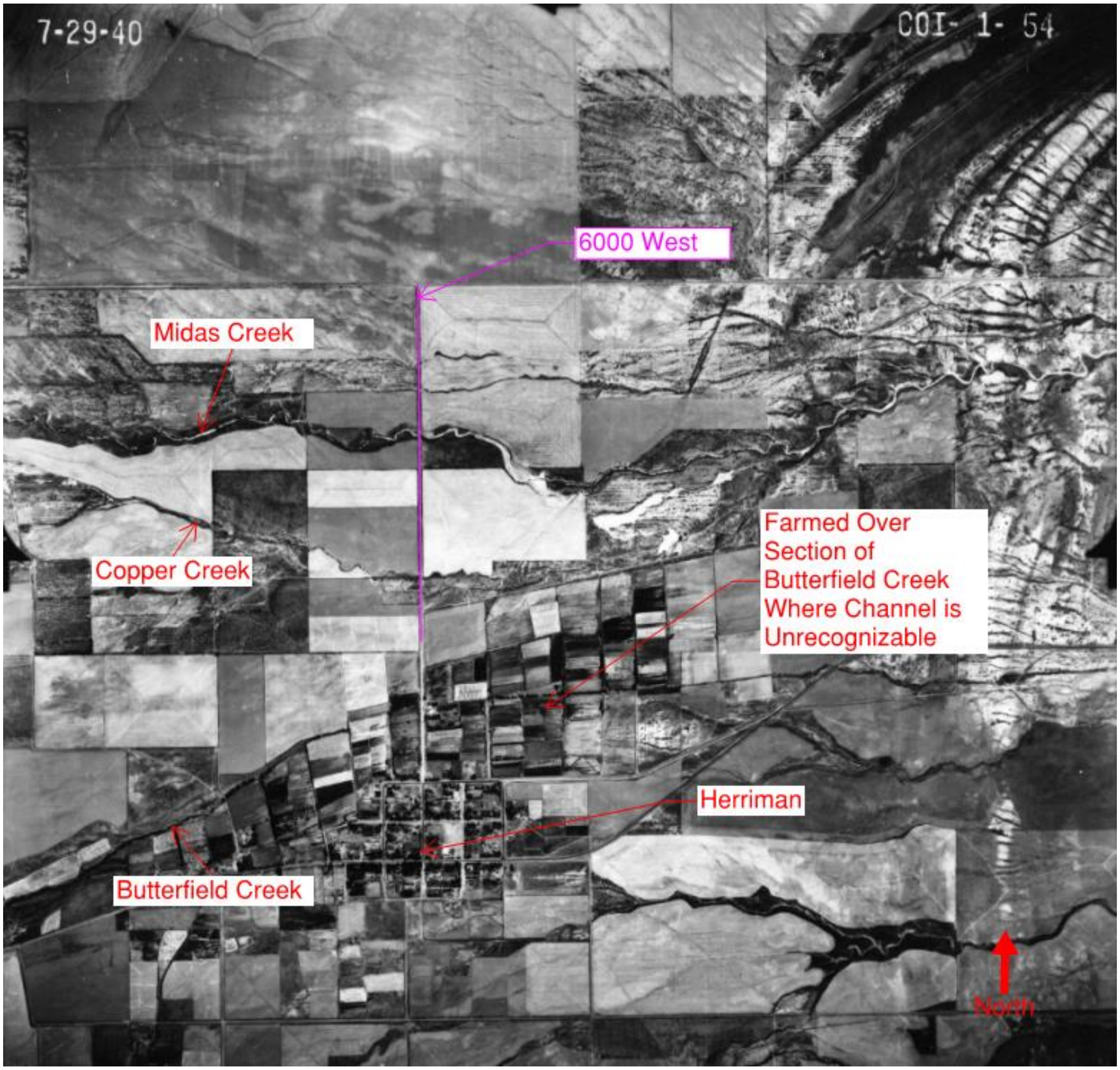

Photo 4-1 – Historic Aerial Photo from 1940

Photograph 4-1 also provides visual evidence that the pre-developed conditions did not produce many significant runoff events. This generally supports the design storm runoff values estimated by StreamStats and ASSA. Additional historic aerial photos from 1937, 1940, 1985 and 1997 are included in Appendix E.

HYDROLOGIC MODELING ASSUMPTIONS

The following general assumptions were made in completing the hydrologic analyses of the study area:

1. Rainfall return frequency is equal to associated runoff return frequency.
2. Design storm rainfall has a uniform spatial distribution over each drainage basin.
3. Normal (SCS Type 2) antecedent soil moisture conditions exist at the beginning of the design storm.
4. The hydrologic computer model adequately simulates watershed response to precipitation.

Storm Drain Inlet and System Capacity

The urban storm drain systems in the cities of South Jordan, Herriman and Riverton are generally designed to collect and convey runoff from a 10-year design storm. The design storm associated with this study was the 100-year storm, or one that has a one percent chance of occurring in any given year. A preliminary analysis of the storm drain inlet and pipe capacities in the developed portions of South Jordan, Herriman and Riverton indicated that most of those facilities in the study area do not have capacity to collect and convey runoff from the 100-year design storm. During larger storm events the streets with curb and gutter become the major storm water conveyance system. Because Midas Creek is the low point of the drainage system, most of the storm water runoff from a major storm that is being conveyed in the streets will still be conveyed to Midas Creek, even though it may follow a different path than the storm drain pipe network in getting to the creek. Because Midas Creek is low point of the drainage system, and because the purpose of this study was to analyze Midas Creek, the conservative assumption was made that all runoff from the 100-year design storm would ultimately conveyed to Midas Creek.

FUTURE DEVELOPMENT CONDITIONS MODELING CONSIDERATIONS

The Utah Department of Environmental Quality and EPA recently made changes to the MS4 Permits for Herriman, South Jordan, and Riverton. Those changes require that Low Impact Development (LID) practices be implemented with development (where feasible) and that all new development and redevelopment retain onsite runoff produced from the 80th-percentile storm. The 80^{th}-percentile storm occurs quite frequently. The storm depth of the 80^{th}-percentile storm in the Midas Creek areas has been estimated to be 0.47 inches, or about 24 percent of the 100-year design storm depth of 1.92 inches. Since this is a large-scale study and since the runoff volume from produced from developed areas during the 100-year design storm will far exceed the design capacity of LID facilities that are designed for the 80^{th}-percentile storm, the conservative assumption was made that LID improvements from future development would not have a significant impact on the peak discharge values experienced on the creeks in the study area.

It was assumed that detention facilities will be needed to attenuate peak runoff discharges associated with future development. This was generally accomplished by simulating a detention facility in each subbasin to limit peak discharge to a desired peak flow rate. Multiple allowable discharge rates were evaluated and will be discussed in Chapter 6.

RESULTS & CONCLUSIONS

The estimated peak 100-year design storm discharge rates in Midas Creek from the existing conditions hydrologic model are summarized in Table 4-5. Also included in Table 4-5 are the runoff values from the projected full build-out conditions from the 2002 SWCCS and the FEMA Flood Insurance Study that is currently out in draft form.

Table 4-5
Estimated 100-Year Peak Discharge Rates in Midas Creek (cfs)

Location	City	Preliminary FEMA 100-Year Discharge	2002 Southwest Canal and Creek Study (Full Build-out Conditions)[1]	Existing Conditions
River Front PKWY[2]	South Jordan	890	865	770
Beckstead Ditch[2]	South Jordan	890	865	770
Chapel Ridge Dr. [2]	South Jordan	890	865	760
South Jordan Canal[2]	Riverton	890	865	720
Gold Dust Dr. [2]	South Jordan	890	865	670
Eureka Way[2]	South Jordan	890	830	670
Utah & Salt Lake Canal[2]	Riverton	735	830	670
2700 West[2]	South Jordan	735	830	550
3200 West[2]	South Jordan	735	830	520
11800 South/Utah Lake Distribution Canal[2]	South Jordan	735	770	520
Janice Dr./3400 West[2]	Riverton	844	770	540
3600 West[2]	Riverton	844	810	540
Bangerter Hwy[2]	Riverton	495	810	540
4000 West[2]	Riverton	495	810	530
Welby Jacob Canal[2]	Riverton	497	805	510
Park Haven Ln. (4510 W) [2]	Riverton	503	805	500
Midas Vista Rd (4775 W) [2]	Herriman	503	805	490
North Bound MVC[2]	Herriman	503	805	470
South Bound MVC[2]	Herriman	503	805	420
Anthem Park Blvd	Herriman	503	620	360
6000 West	Herriman	503	620	80
~7000 West Farm Bridge	Unincorporated County	-	-	60
Bacchus Hwy	Unincorporated County	-	-	50
Private Road Upstream of Bacchus Hwy	Unincorporated County	-	-	30

[1] Assuming Future Development detains peak discharges to 0.2 cfs/ac
[2] Peak discharge includes an Areal Reduction Factor

The estimated peak 100-year design storm discharge rates in Butterfield Creek from the existing conditions hydrologic model are summarized in Table 4-6. Also included in Table 4-6 are the runoff values from the projected full build-out conditions from the 2002 SWCCS. The FEMA Flood Insurance Study does not include flow rates for Butterfield Creek.

Table 4-6
Estimated 100-Year Peak Discharge Rates in Butterfield Creek (cfs)

Location	City	2002 Southwest Canal and Creek Study (Full Build-out Conditions)[1]	Existing Conditions
Herriman Main Street	Herriman	200	150
Koppers Lane	Herriman	200	150
Pipeline from 5600 West to End	Herriman	200	140
Pipeline from Herriman Blvd to 5600 West	Herriman	200	120
Pipeline from Silver Sky Dr. to Herriman Blvd	Herriman	200	120
Pipeline from Entrance to Silver Sky Dr.	Herriman	200	120
Inlet to Pipe Network	Herriman	200	120
Hidden Oaks Culvert 3 (aprox. 6600 W)	Herriman	N/A	110
Hidden Oaks Pipeline (aprox. 6700 W)	Herriman	N/A	110
Hidden Oaks Culvert 2 (aprox. 7075 W)	Herriman	N/A	110
Hidden Oaks Culvert 1 (aprox. 7550 W)	Herriman	N/A	50
Bacchus Hwy	Unincorporated County	N/A	20
Farm Road US of Baccus	Unincorporated County	N/A	20
Access Road US of Baccus	Unincorporated County	N/A	20

[1] Assuming Future Development detains peak discharges to 0.2 cfs/ac

There are two key conclusions that can be made from the hydrologic modeling work summarized in this chapter.

1. The existing conditions discharge rates identified in Table 4-5 and Table 4-6 are slightly lower than the projected build-out peak discharge rates identified in the 2002 SWCCS. The existing conditions flow rates on Table 4-6 are lower than the Preliminary FEMA 100-year discharge values. The 2002 SWCCS analyses were based on assumptions that certain areas within the Midas Creek and Butterfield Creek Drainage areas would not develop and that those undeveloped areas would discharge at a pre-development flow rate (generally between 0.02-0.05 cfs/ac for the 100-yr storm). Those development assumptions were based on land-use and zoning plans that existed when that study was completed. The land-use and zoning in the area has significantly changed since 2002. Many areas that were originally anticipated to remain as open space and have design storm discharge rates of approximately 0.02 cfs/acre have either developed with an allowable peak discharge rate of 0.2 cfs/acre or now have plans to develop in the near future. These changes are one of the

key reasons that the SWCCS is being updated. This study needs to identify recommended discharge restrictions for areas that remain to be developed. This will be addressed in Chapter 6.

2. It is estimated that there are 2170 acres of land planned for development in the Midas Creek drainage basin and more than 500 acres of land planned for development in the Butterfield Creek drainage basin. If those areas develop, many of which were not planned to develop when the 2002 SWCCS was completed, and are allowed to discharge storm water at a rate of 0.2 cfs/acre, it is likely that the design storm discharges from projected full build-out conditions will significantly exceed the future development discharges estimated during the 2002 SWCCS. This issue will also be addressed in Chapter 6.

CHAPTER 5
HYDRAULIC ANALYSES

Hydraulic analyses were performed of the Midas Creek and Butterfield Creek channels in the study area with the associated culverts and bridges to estimate existing capacities and to determine existing conveyance capacities and to identify where existing capacity deficiencies exist in the study area. This chapter summarized how the hydraulic analyses were performed.

FEMA is currently in the process of updating the Flood Insurance Rate Maps (FIRMs) in Salt Lake County. As part of that project, a HEC-RAS model of Midas Creek was developed from the Utah Lake Distribution Canal to the Jordan River. That FEMA HEC-RAS model was provided to BC&A by the County and then BC&A performed additional work to extend that model from the Utah Lake Distributing Canal westward to the foot of the Oquirrh Mountains.

HEC-RAS hydraulic computer model of Butterfield Creek and of the reach of Midas Creek and that extends from the foot of the Oquirrh Mountains to the Utah Lake Distributing Canal were developed utilizing topographic data, survey data of channel cross sections and hydraulic structures, and aerial photographs. Version 5.0.1 of the HEC-RAS computer program developed by the United States Army Corps of Engineers was used to perform the hydraulic modeling for this study. The purpose of this chapter is to describe the process used to develop the hydraulic models and to summarize the modeling results associated with the hydraulic analyses.

HYDRAULIC MODEL DEVELOPMENT

This section outlines the general methodology and approach used to complete the hydraulic modeling of the creek channels that were studied in detail as part of this project.

Basic Information

Data acquisition and hydraulic model development tasks were completed in accordance with FEMA Guidelines and Specifications.

Topographic Data

Channel cross sections were surveyed at approximately 500-foot intervals through the study reaches of Midas Creek and Butterfield Creek. Then 2013-14 LiDAR data from AGRC were used in conjunction with HEC-RAS to extend the limits of the surveyed channel cross sections across the channel overbanks to obtain needed cross section geometric data needed to develop the open channel model. Field survey data of hydraulic structures were used to develop the geometry data for hydraulic structures on the creeks.

Downstream Boundary Conditions

Midas Creek discharges to the Jordan River. The downstream boundary condition was included with the FEMA portion of the Midas Creek Model. The downstream boundary condition was a normal depth calculation with a slope of 0.00071 ft/ft.

Manning's "n" Values and Expansion/Contraction Coefficients

Values for channel overbank roughness coefficients, or Manning's "n" coefficients, were estimated based on field observations, hydraulic modeling literature, aerial photography, and engineering judgment. As a general rule, Manning's "n" values were selected that would result in subcritical flow conditions. Generally, the Manning's "n" value used for the overbank was between 0.040 and

0.080, and a value of 0.035 was used for the channel. Those Manning's "n" values are within an acceptable range that reflect the channel conditions.

Stream Layout and Cross-section Locations

The Midas Creek and Butterfield Creek centerline locations were digitized using the ArcGIS software and the 2018 High Resolution Orthophotography (HRO), available from Utah's Automated Geographic Reference Center (AGRC) website. Channel cross sections were surveyed and entered into the hydraulic model at intervals of about 500 feet. The cross sections included the top of bank, toe of channel banks, flow line and other grade breaks. The geometry data for the overbank areas for the cross sections were collected by extending the cross sections limits across the overbank and floodplain limited using the digital 2013-14 LiDAR data and GIS tools. Survey data of the hydraulic structures were used to develop the geometry data for hydraulic structures on Midas Creek and Butterfield Creek. The models include approximately 500 cross sections and 50 structures.

CALIBRATION

Calibration of a hydraulic computer model generally consists of measuring actual flow conditions in the field and comparing these measurements with those predicted by the model. Because of the ephemeral nature of Midas and Butterfield Creeks, no data was collected for calibration. Without calibration data, the validity of the model results will be directly tied to the accuracy of the initial, visual assessment of the creek. Since this is the case, a detailed photographic log of Midas Creek and Butterfield Creek has been included in Appendix A of this report.

Most of the Midas Creek and Butterfield Creek channels are relatively steep with slopes ranging from 1 to 3 percent. Because the slopes are relatively high, the culverts and bridges will be inlet controlled. The capacity of the culverts from the HEC-RAS model were compared to inlet control nomographs from the UDOT Drainage Manual of Instruction (MOI) for the culverts and bridges. The results of culvert capacity analysis are summarized in Table 5-1.

Table 5-1
Estimated Hydraulic Capacities for Existing Culverts and Bridges

Culvert or Bridge Location	Existing Culvert Size	Estimated Hydraulic Capacity Using an Inlet Control Nomograph (cfs)	Estimated Hydraulic Capacity for Culverts from HEC-RAS (cfs)
Midas Creek			
River Front PKWY (approximately 900 W)	Two 13'X7' Box Culverts	2030	2130
Beckstead Ditch (approximately 1000 W)	15'X6'	1050	1130
Private Road DS of Park Palisade Dr. (approximately 1150 W)	12'X6'	1200	1180
Park Palisade Dr. (approximately 1250 W)	15'X4.5'	900	920
Chapel Ridge Dr. (approximately 1250 W)	21.5'X6.2'	1290	1340
Private Dr. DS of 1300 West	20'X8'	1900	1860
1300 West	Two 8.5'X4' Box Culverts	770	730
11500 South Street	14'X4'	910	910
South Jordan Canal	10'X5'	950	960
Private Dr. DS of Redwood Rd. (approximately 1600 W)	15'X5'	825	790
Private Dr. DS of Redwood Rd. (approximately 1650 W)	14'X5'	630	630
Redwood Rd	18'X5'	1080	1080
Winford Dr. (approximately 1830 W)	Two 7'X6' Box Culverts	910	930
Gold Dust Dr. (approximately 2000 W)	Two 9'X5' Box Culverts	990	950
Eureka Way (approximately 2150 W)	Two 5' RCP	230	230
Downstream of Utah & Salt Lake Canal	10'X7'	1100	1090
2700 West	16'X7'	910	870
3200 West	18'X7'	900	800
11800 South/Utah Lake Dist Canal	Two 5' RCP	700	710
Janice Dr./3400 West	20'X4'	750	770
3600 West	5' and 6' Diameter Culverts	420	470
Bangerter Hwy	18'X9'	2610	2400
4000 West	14'X6'	910	980
Swensen Farms Dr. (4370 W)	10'X5'	650	690
Park Haven Ln. (4510 W)	15'X8'	1200	1200
Midas Vista Rd (4775 W)	10'X6'	1000	970
Black Powder Drive (4895 W)	10'X6'	870	840
7000 West Farm Bridge	15" Culvert	10	10
Bacchus Hwy	4' CMP	140	130
Private Road Upstream of Bacchus Hwy	Two 21" Culverts	50	50

Table 5-1(continued)
Estimated Hydraulic Capacities for Existing Culverts and Bridges

Culvert or Bridge Location	Existing Culvert Size	Estimated Hydraulic Capacity Using an Inlet Control Nomograph (cfs)	Estimated Hydraulic Capacity for Culverts from HEC-RAS (cfs)
Butterfield Creek			
Herriman Main Street	8' X 5' Box Culvert	400	340
Koppers Lan (approximately 5250 W)	8' X 5' Box Culvert	520	480
Herriman Parkway (Downstream End)	5' RCP	Downstream Controlled	200
Herriman Parkway (6000 W)	5' RCP	Downstream Controlled	200
Herriman Parkway (Upstream End)	4' RCP	140	140
Hidden Oaks Culvert 3 (approximately 6600 W)	5.5' RCP	260	260
Hidden Oaks Pipeline (approximately 6700 W)	5.5' RCP	300	310
Hidden Oaks Culvert 2 (approximately 7075 W)	5.5' RCP	160	150
Hidden Oaks Culvert 1 (approximately 7550 W)	5.5' RCP	180	190
Bacchus Hwy	4' RCP	110	150
Farm Road Upstream of Bacchus Hwy (approximately 8400 W)	3.5' CMP	70	70
Access Road Upstream of Bacchus Hwy (approximately 8450 W)	4' CMP	170	170

As can be seen in Table 5-1, the HEC-RAS model results for each of the structures are similar to the inlet control nomographs, and the structure modeling did not need to be modified.

A stream gage was installed by Salt Lake County on Midas Creek in 2014. However, there is not enough data available from that gage to provide calibration data on the Midas Creek model.

RECOMMENDED CHANNEL FREEBOARD

The recommended minimum freeboard on Midas Creek is two feet for design and capacity evaluation purposes. In performing the detailed hydraulic analyses, channel reaches where the hydraulic model indicates that there is at least two feet of freeboard were considered to have adequate capacity to convey the 100-year design discharge. If an area had between zero and two feet of freeboard (i.e. is it not flooding, but has little freeboard), it was considered to have a potential capacity deficiency, but no project would be considered to increase capacity or freeboard. If the hydraulic computer model predicts that a reach of channel may be overtopped during the estimated 100-year design discharge, that reach would be considered to have a capacity deficiency and a project to mitigate that deficiency would ultimately be identified. Culverts and bridges were considered to be capacity deficient if they overtopped, or if they restricted flow in the channel and created an upstream freeboard deficiency.

HYDRAULIC MODELING RESULTS

The hydraulic models of the creeks were run for the 100-year design storm peak discharges associated with existing development conditions identified in Chapter 4. The model was run with steady-state flow rates. The results of those runs are included on Figures 5-1 and 5-2. Observations about culvert information illustrated on Figures 5-1 and 5-2 is presented below. The profile for the results are included in Figures 5-3 to 5-12. These figures include all alternatives analyzed.

Midas Creek Existing Conditions Model Results

Figure 5-1 identifies the freeboard and culvert deficiencies on Midas Creek for the design storm peak discharge rates associated with existing development conditions. There are ten existing culvert capacity deficiencies located at: Private Road downstream of Park Palisade Dr., Private Foot Bridge downstream of Park Palisade Dr., Park Palisade Dr., 1300 West, 11500 South Street, Private Dr. downstream of Redwood Rd., Eureka Way, 3600 West, Welby Jacobs Canal, and the 7000 West Farm Bridge. Though ten culverts are capacity deficient, only seven of those culverts are recommended to be replaced to mitigate the existing capacity problem, as described below.

- **Private Road downstream Park Palisade Dr., Private Foot Bridge downstream Park Palisade Dr. and Park Palisade Dr. (Approximately 1200 West and 12600 South)** – The Private Road downstream Park Palisade Dr. can safely convey the 100-year flow, but only if the culvert surcharges two-and-a-half feet above the top of the culvert opening. The backwater from the culvert causes flooding upstream at the private pedestrian bridge downstream of Park Palisade Dr. In addition, the channel slope through this section is minimal or even adverse. This, combined with backwater from the private road downstream of Park Palisade Dr., causes water to overtop Park Palisade Dr. If the culvert at the private road downstream of Park Palisade Dr. and the channel were to be improved, improvements at the two upstream culverts (private pedestrian bridge and Park Palisade Dr.) would not need to be required.
- **1300 West and 11500 South Street –** The culvert under 1300 West can safely convey the 100-year design discharge, but surcharges water over the top of the culvert by about 5.5 feet. Backwater from the 1300 West culvert causes upstream flooding that extends to the 11500 South culvert. If the 1300 West culvert is replaced or improved, the 11500 South culvert would have adequate capacity.
- **Private Drive downstream of Redwood Rd., Eureka Way, 3600 West, Welby Jacobs Canal, and 7000 West Farm Bridge -** The culvert capacity deficiencies at the Eureka Way, 3600 West, Welby Jacobs Canal, and 7000 West crossings will need to be mitigate by replacing the undersized culverts.

There are also areas where channel capacity deficiencies result in some flooding, as described below.

- **Near 1200 West** - There are major channel capacity deficiencies between 11400 South and 11000 South at approximately 1200 West. The existing channel does not have capacity to safely convey the 100-year flood event and there are lawns, gazebos, basketball courts and houses immediately adjacent to the banks of the Midas Creek Channel. The preliminary FEMA floodplain included in Figure 5-1 and in Appendix B shows yards and houses in the 100-year floodplain in this area. Even if the culverts in this area are improved, the channel will not have capacity to safely convey the 100-year design discharge.

Improvements to the channel in this area would be difficult to construct because there is no access to the Midas Creek channel in this area. There are several private amenities like basketball courts and gazebos right next to Midas Creek. Property owners in the area will be hesitant to allow the County to access the Creek through their property. It will be difficult to construct improvements to the channel through this area because of the extensive coordination with property owners that would be required to obtain the necessary permissions and temporary construction easements.

- **Near 1300 West** - There is a significant channel capacity deficiency immediately upstream of 1300 West. The predicted flooding in this area is caused by the undersized culvert at 1300 West. If that culvert is upsized, it would significantly reduce the potential for flooding in this area. However, there is a house on the west side of Midas Creek, between 1300 West and 11500 South, that still would have the potential to flood during a 100-year design storm event.
- **Between 2700 West and Utah Lake Distribution Canal** – The preliminary FEMA floodplain maps identify a newly-developed area adjacent to Midas Creek between 2700 West and the USLC is located within the 100-year floodplain. It appears that the flood hazard shown on the Preliminary FEMA Flood Insurance Rate Map (FIRMs) is not associated with a channel capacity deficiency, but rather an uncertified levee. Once the preliminary FEMA FIRMs become the effective floodplain maps, several houses in that area are going to be required to purchase flood insurance policies. If improvements are made to the channel or the levee the floodplain maps could be updated to remove those houses from the floodplain in the area. It is important to note that the channel does not appear to be capacity deficient, and therefore, has not been identified as a deficiency on any figures.

There are also some additional existing channel capacity deficiencies at other various locations identified on Figure 5-1. The other deficiencies are minor and are not likely to cause property damage if there is a 100-year flood event. Aside from the previously mentioned capacity deficiencies, the majority of Midas Creek channel has capacity to safely convey the 100-year discharge associated with the existing development conditions.

Butterfield Creek Existing Conditions Model Results

As shown in Figure 5-2, there is only one capacity deficiency on Butterfield Creek associated with the 100-year design storm for existing development conditions. The deficiency is at approximately 8000 West and is in an area where farming activities have encroached into the channel as identified in Chapter 2. That deficiency is in an undeveloped area, and flooding is unlikely to cause significant damage in that area. The channel will need to be improved when the area develops.

CONCLUSIONS AND RECOMMENDATIONS

The hydraulic analysis of the existing creek channels in the study area resulted in the following major conclusions.

- Some segments of Midas Creek do not have capacity to safely convey the peak 100-year design discharge rate. Several projects will be required to mitigate the capacity deficiencies along the Midas Creek channel so it can safely convey the 100-year discharge to the Jordan River without damaging existing homes and structures.
- With the existing deficiencies, Midas Creek does not have capacity to receive any additional storm water runoff from future development without making the existing problems worse

and potentially creating new problems or deficiencies. Alternative methods that could be implemented to resolve the existing deficiencies and safely manage runoff from future development will be addressed in Chapter 6.

- The discharges used by FEMA to develop the 100-year floodplain along Midas Creek are higher than the 100-year discharges associated with existing development conditions. This means that some of the flooding problems shown on the preliminary FEMA Flood Insurance Rate Maps may not be as severe as they are illustrated. In evaluating improvement alternatives and future development criteria, it is recommended that an effort be made to limit the projected future develop discharges to be less than or equal to the existing FEMA 100-year discharge values so that no new flood hazards are created.

CHAPTER 6
ALTERNATIVES ANALYSIS AND RECOMMENDATIONS

INTRODUCTION

The primary purpose of this study is to update the hydrologic and hydraulic analyses of the Midas Creek drainage basin. Midas Creek is one of 58 multi-jurisdictional facilities for which Salt Lake County has management jurisdiction. As indicated in Chapter 5, the results of this study and the preliminary flood insurance rate maps that were recently prepared by FEMA for Midas Creek both indicate that the creek currently has flooding issues in South Jordan between 11400 South and the culvert approximately 1,000 feet north of Park Palisade Drive. Since there are some large tracts of land that are planned for development in the southwest part of Salt Lake County, the County is working with representatives from Herriman, Riverton and South Jordan to determine how runoff from the future development in the Midas Creek drainage area should be managed so that it does not create additional flood hazards along the creek.

Salt Lake County published the Southwest Canal and Creek Study in 2002. As part of that study, detailed hydrologic and hydraulic analyses were performed for Midas Creek based on soils, zoning, and projected land use plans provided by Salt Lake County and each of the incorporated cities in the study area. That study has been used as the basis for sizing culverts on Midas Creek and managing storm water runoff in the Midas Creek drainage area. Two of the general criteria that were used in completing that study include:

- Areas that were then zoned or planned for development would be required to release storm water discharges associated with development (including roads and streets) at a peak rate of 0.2 cfs per acre.
- Areas that were not identified as areas of potential development would not be developed. This means that there would be no change in runoff peaks or volumes in the future.

When land is developed, ground cover and drainage patterns change. Those changes typically result in significant alterations to the natural hydrology of a site that include an increased runoff volume, an increase peak flow of runoff, increased duration of discharge, and increased pollutant loading. The EPA, through the MS4 Permitting Program, has required that new development in Utah retain onsite all runoff from the 80th percentile storm. The intent of this requirement is to restore post-development runoff conditions to pre-development conditions with regard to volume, flow rate, duration, and infiltration.

In the past, Salt Lake County and many cities in Utah have required that new development limit peak storm water discharges to 0.2 cfs per acre. The general intent of this requirement was to limit the peak discharge from a developed site to pre-development conditions. However, it did not address the other issues associated with volume, duration of flow, and pollutant loading. In large part, the 0.2 cfs/acre discharge limitation has been generally applied across the Salt Lake Valley and the State of Utah without regard to the actual predevelopment runoff characteristics that vary from location to location. The 0.2 cfs per acre peak discharge rate is much higher that pre-development conditions in many areas. Many entities in Salt Lake County that utilize the 0.2 cfs per acre discharge limit also use more restrictive discharge limits in areas where there is limited capacity in downstream drainage facilities. For instance, for several years Herriman City has required all development in the south part of the city in the Rose Creek drainage basin to detain to 0.02 cfs per acre, which generally represents the pre-development discharge rate. Herriman also recently adopted the same 0.02

cfs/acre discharge limitation for undeveloped land in the Midas Creek drainage basin. That discharge rate was based on analyses performed as part of a master planning process. Salt Lake City and West Valley City require peak discharges of 0.1 cfs per acre or less in some parts of those cities.

Many areas in the southwest quadrant of Salt Lake County have experienced changes to development patterns that were not anticipated in 2002. Some areas that were planned to develop at lower densities have developed at higher densities and thousands of acres that were planned to remain undeveloped have developed or are in the process of developing. These changes all have an impact to the runoff that drains to Midas Creek. Since most of the development potential in the drainage basin is in the upper portion of the drainage basin, runoff from the large developing areas impacts culverts and channel reaches in downstream areas that are already built out. Chapters 4 and 5 of this report summarize the results of the hydrologic and hydraulic conditions that currently exist in the Midas Creek drainage basin. This chapter will present how implementing various development and storm water discharge limitation scenarios could affect flood hazards along Midas Creek.

In evaluating potential alternatives to manage runoff from future development, the hydrologic model for existing development conditions in the study area was revised to estimate peak discharges at key locations along Midas Creek for a range of scenarios that include the following:

Alternative 1 – All future development would retain storm water runoff from onsite from the 100-year design storm to limit storm water discharges to predevelopment flow rates.

Alternative 2 – All future development would construct storm water management facilities to limit post-development 100-year discharges to 0.2 cfs/acre into Midas Creek and Butterfield Creek.

Alternative 3 – All future development would construct storm water management facilities to limit post-development 100-year discharges to 0.02 cfs/acre into Midas Creek and Butterfield Creek. One of the goals with this alternative would be limit peak discharges to pre-development conditions, and to keep the peak flow below the FEMA preliminary flow rate.

Alternative 4 – All future development would construct storm water management facilities to limit post-development 100-year discharges to 0.10 cfs/acre into Midas Creek and Butterfield Creek.

Alternative 5 – Construct a large regional in-stream storm water detention facility immediately upstream of Mountain View Corridor to attenuate future 100-year peak discharges to a level that would be at or below the peak 100-year discharges associated with existing development conditions.

Alternative 6 – Construct a large storm drain pipe along 11400 South from about 1200 West to the Jordan River.

The peak design storm discharges associated with each of these alternatives was then used to update the existing-conditions hydraulic model described in Chapter 5 to identify how implementing each alternative would impact the existing channel and culvert/bridge capacity deficiencies identified in Chapter 5.

Computed peak 100-year design storm discharge rates for each of these alternatives are presented in Table 6-1 and Table 6-2. A discussion of the hydraulic impacts that implementing each of the evaluated alternatives would have on the capacity and flood potential along Midas Creek and Butterfield Creek is discussed below.

As stated in previous chapters, FEMA is in the process of updating the FIRMs through-out Salt Lake County, including Midas Creek. Those FEMA floodplain maps identify some channel and culvert deficiencies along Midas Creek. The flow rates for each of the alternatives were compared to the FEMA flow rates in an effort not to increase the flood hazards on Midas Creek.

Table 6-1 (continued)
Summary of 100-year Peak Flows in Midas Creek Associated with Evaluated Alternatives[1]

Location	City	HEC-RAS Cross Section Station (Measured in feet from the confluence with the Jordan River)	Preliminary FEMA FIS Flow Rate	Existing Conditions	Alternative 1 – Future Development Retains (cfs)	Alternative 2 – Future Development Discharges at 0.2 cfs/ac (cfs)	Alternative 3 – Future Development Discharges at 0.02 cfs/ac (cfs)	Alternative 4 – Future Development Discharges at 0.1 cfs/ac (cfs)	Alternative 5 – Inline Regional Detention Facitliy (cfs)
River Front PKWY	South Jordan	649	890	770	770	1180	870	1010	780
Beckstead Ditch	South Jordan	1123	890	770	770	1180	870	1010	780
Park Palisade Dr	South Jordan	4179	890	760	760	1170	850	1000	770
11400 South	South Jordan	5769	890	760	760	1160	850	1000	770
Chapel Ridge Dr.	South Jordan	6148	890	760	760	1160	850	1000	760
South Jordan Canal	Riverton	9097	890	720	720	1130	810	960	730
Redwood Rd	Riverton	10455	890	670	670	1070	760	910	670
Gold Dust Dr.	South Jordan	12182	890	670	670	1070	750	900	670
Downstream of Utah & Salt Lake Canal	Riverton	14401	890	670	670	1070	750	900	670
2700 West	South Jordan	16111	735	550	550	950	640	790	550
3200 West	South Jordan	18868	735	520	520	920	600	760	520

Table 6-1 (continued)
Summary of 100-year Peak Flows in Midas Creek Associated with Evaluated Alternatives[1]

Location	City	HEC-RAS Cross Section Station (Measured in feet from the confluence with the Jordan River)	Preliminary FEMA FIS Flow Rate	Existing Conditions	Alternative 1 – Future Development Retains (cfs)	Alternative 2 – Future Development Discharges at 0.2 cfs/ac (cfs)	Alternative 3 – Future Development Discharges at 0.02 cfs/ac (cfs)	Alternative 4 – Future Development Discharges at 0.1 cfs/ac (cfs)	Alternative 5 – Inline Regional Detention Facitliy (cfs)
11800 South/Utah Lake Dist Canal	South Jordan	20161	735	520	520	920	600	760	520
Janice Dr./3400 West	Riverton	20947	844	540	540	940	580	730	490
Bangerter Hwy	Riverton	24382.8	495	540	540	940	580	730	490
4000 West	Riverton	24992	495	530	530	930	580	720	480
Welby Jacob Canal	Riverton	27366	497	510	510	910	550	700	460
Park Haven Ln. (4510 W)	Riverton	28615	503	500	500	910	550	700	450
Midas Vista Rd (4775 W)	Herriman	30629	503	490	490	910	530	680	440
North Bound MVC	Herriman	32518	503	470	470	910	520	680	430
South Bound MVC	Herriman	35097	503	420	420	870	480	640	390

Table 6-1 (continued)
Summary of 100-year Peak Flows in Midas Creek Associated with Evaluated Alternatives[1]

Location	City	HEC-RAS Cross Section Station (Measured in feet from the confluence with the Jordan River)	Preliminary FEMA FIS Flow Rate	Existing Conditions	Alternative 1 – Future Development Retains (cfs)	Alternative 2 – Future Development Discharges at 0.2 cfs/ac (cfs)	Alternative 3 – Future Development Discharges at 0.02 cfs/ac (cfs)	Alternative 4 – Future Development Discharges at 0.1 cfs/ac (cfs)	Alternative 5 – Inline Regional Detention Facitliy (cfs)
Herriman Main Street	Herriman	32965	503	350	350	630	320	450	630
Anthem Park Blvd	Herriman	37455	503	360	360	640	330	450	630
6000 West	Herriman	40357	503	80	80	480	100	270	480
~7000 West Farm Bridge	Unincorporated County	48108	N/A	60	60	210	70	130	210
Bacchus Hwy	Unincorporated County	53302	N/A	50	50	50	50	50	50
Private Road Upstream of Bacchus Hwy	Unincorporated County	56286	N/A	30	30	30	30	30	30

[1] Alternative 6 is not included in the table because if it is implemented, it will be paired with another alternative.

Table 6-2
Summary of 100-year Peak Flows in Butterfield Creek Associated with Evaluated Alternatives[1]

Location	City	HEC-RAS Cross Section Station (Measured in feet from the confluence with the Jordan River)	Preliminary FEMA FIS Flow Rate	Existing Conditions	Alternative 1 – Future Development Retains (cfs)	Alternative 2 – Future Development Discharges at 0.2 cfs/ac (cfs)	Alternative 3 – Future Development Discharges at 0.02 cfs/ac (cfs)	Alternative 4 – Future Development Discharges at 0.1 cfs/ac (cfs)	Alternative 5 – Inline Regional Detention Facitliy (cfs)
Koppers Lane	Herriman	2626	N/A	140	140	300	150	220	300
Pipeline at 5600 West	Herriman	N/A	N/A	140	140	300	140	220	300
Pipeline at 6000 West	Herriman	N/A	N/A	90	90	290	110	210	290
Upstream End of Pipeline	Herriman	12519	N/A	80	80	210	90	150	210
Hidden Oaks Culvert 2 (approx. 7075 W)	Harriman	18104	N/A	50	50	150	50	120	150
Hidden Oaks Culvert 1 (approx. 7550 W)	Harriman	22199	N/A	50	50	60	20	40	60
Bacchus Hwy	Unincorporated County	25413	N/A	20	20	20	20	20	20
Access Road US of Bacchus Hwy	Unincorporated County	27749	N/A	20	20	20	20	20	20

[1] Alternative 6 is not included in the table because if it is implemented, it will be paired with another alternative.
[2] There are no published FEMA flow rates for Butterfield Creek.

Alternative 1 – Future Development Retains Storm Water Runoff On-Site

Alternative 1 assumes that all future development in the Midas Creek and Butterfield Creek drainage area will be required to retain all storm water runoff from impervious areas in new development on-site until it infiltrates into the ground, or until it could be pumped into the storm drain system after the peak flow has passed. If this alternative is implemented, the existing 100-year peak flow in Midas Creek and Butterfield Creek in the future would not increase. The recommended improvements to Midas Creek and Butterfield Creek identified in Chapter 5 as part of the existing conditions analysis will be the only improvements needed to safely convey storm water runoff in Midas Creek to the Jordan River. Figures 5-1, 5-2, 6-1.1 and 6-1.2 identify the deficiencies, improvements and conceptual cost estimate associated with this alternative.

The conceptual cost associated with the improvements to Butterfield and Midas Creeks would be $5.7 million in 2020 dollars. The detailed cost estimate can be found in Appendix F. These costs do not include the costs of the retention facilities that will be required to ensure no runoff from future development will reach Butterfield or Midas Creeks. It was assumed that each development would construct the facilities to retain runoff from the developed areas. This retention requirement would also need to apply to all new streets, regardless of ownership.

Butterfield and Midas Creeks are the low point of the storm drain system in the study area, and not allowing storm water runoff from new development to discharge to the creeks would be a burden on developers, Cities, and the County. Developers would be required to construct many small local retention basins and possibly some pump stations to discharge storm water after the peak flow has passed. This would represent a significant cost to the developers. Cities or the County may need to own or maintain those retention facilities placing undue burden on their maintenance crews. Because of these reasons, this alternative is not considered to be feasible.

Alternative 2 – Future Development Discharges at 0.2 cfs/ac

The County's policy for peak storm water discharge rates on Midas Creek has been to allow areas that were zoned or planned for development in 2002 to discharge at 0.2 cfs/ac. If the County continues to allow future development to discharge at 0.2 cfs/ac into Midas Creek, the peak flow rate in Midas Creek will increase significantly. This alternative includes allowing future development to discharge runoff from a 100-year storm to Butterfield and Midas Creeks at a peak rate of 0.2 cfs/acre. The peak flow rate in Midas Creek will significantly increase, exceeding the flow rates identified by the FEMA preliminary study. It will create several new culvert and channel capacity deficiencies in Midas Creek. Figures 6-2.1, 6-2.2, 6-2.3 and 6-2.4 identify the deficiencies, needed improvements and conceptual cost estimate associated with this alternative.

If future development discharges at a rate of 0.2 cfs/acre, there will be 13 additional culvert projects and several new channel improvements projects on Midas Creek in addition to the improvement projects identified in Chapter 5. This alternative would include replacing several culverts that have been installed in the past 15 years. Butterfield Creek would also have a significant deficiency on Herriman Parkway, requiring that 4700 linear feet of 60-inch RCP be replaced with a 72-inch RCP. The cost to replace that pipe would be significant.

The conceptual cost associated with the improvements to Midas Creek associated with this alternative would be $15.2 million. The detailed cost estimate can be found in Appendix F. This alternative includes significant costs to improve Midas Creek so it can safely convey the 100-year flow rate that were not anticipated in the 2002 SWCCS.

Alternative 3 – Future Development Discharges at 0.02 cfs/ac

The majority of the area that still needs to develop in the Midas Creek drainage area was not zoned or planned for development based on the 2002 SWCCS. To avoid significant increases to the flow rate in Midas Creek, this alternative includes allowing future development to discharge to Butterfield Creek and Midas Creek at pre-development flows, with a peak rate of 0.02 cfs/ac. This alternative has fewer improvement projects than Alternative 2, and it keeps the peak flow rate in Midas Creek below the FEMA flow rate. Figures 6-3.1 and 6-3.2, 6-3.3, 6-3.4 identify the deficiencies, needed improvements and conceptual cost estimate associated with this alternative.

Some of the future flow rates in Butterfield Creek for this alternative are lower than the existing conditions flow rate. The drainage patterns in the Butterfield Creek drainage are changing with the Olympia Hills development. Storm water currently discharging to Butterfield Creek will be re-routed to Midas Creek.

The conceptual cost associated with the capacity-related improvements to Butterfield Creek and Midas Creek would be $6.0 million. The detailed cost estimate can be found in Appendix F.

This option would limit the impact of developers so that flooding on Midas Creek will be no worse than what is defined by the FEMA preliminary floodplain maps. It would allow development to continue to discharge to Butterfield Creek and Midas Creek, but would limit the peak discharge from each developed area to be similar to the pre-conditions flow rate, as is required by the State of Utah.

Alternative 4 – Future Development Discharges at 0.1 cfs/ac

Similar to the previous alternative, this alternative limits the peak discharge in areas that will develop in the future. Rather than allow those areas to discharge at 0.2 cfs/ac, the discharge requirement would be 0.1 cfs/ac. In this scenario, the peak flow in Midas Creek would be higher than the FEMA flow rate, and it would require more projects to improve culverts and the channel than Alternative 3. Figures 6-4.1, 6-4.2, 6-4.3 and 6-4.4 identify the deficiencies, improvements and conceptual cost estimate associated with this alternative.

The conceptual cost associated with the capacity-related improvements to Midas Creek would be $9.3million. The detailed cost estimate can be found in Appendix F. This option would add several new improvement projects to the Midas Creek Channel that were not anticipated in the 2002 SWCCS. The peak flow rate in Midas Creek would be higher than the FEMA flow rate, increasing the potential for flooding in the future.

Alternative 5 – Regional In-Stream Detention Facility

This alternative includes constructing a large in-stream regional detention facility on Midas Creek immediately upstream of the Mountain View Corridor. The detention basin could not be large enough to remove all downstream deficiencies. So rather than remove all deficiencies, the goal of the detention basin would be to limit future discharge rates in Midas Creek to the existing conditions flow rates. This alternative was analyzed with the detention requirement of requiring future development to discharge at a peak rate of 0.2 cfs/ac. This alternative removes many of the culvert and channel deficiencies along Midas Creek. The deficiencies and recommended Midas Creek channel improvements associated with this alterative are identified on Figures 6-5.1, 6-5.2, 6-5.3 and 6-5.4. The detention basin footprint would be approximately 25 acres and the required detention volume would be approximately 85 acre-feet (ac-ft), as shown on Figure 6-5.3. The peak discharge rate from the detention basin would be approximately 310 cfs.

It is important to remember that most of the property near Midas Creek has been developed. Therefore, there is very little open area for a large in-stream detention basin on Midas Creek. The only available area is upstream of the Welby Jacob Canal. That property upstream of the Welby Jacob Canal is prime commercial real-estate and would be extremely expensive to purchase for a storm water management facility. Figures 6-5.1, 6-5.2, 6-5.3 and 6-5.4 identify the deficiencies, improvements and conceptual cost estimate associated with this alternative.

The conceptual cost associated with the improvements to Midas Creek would be $16.6 million. The detailed cost estimate can be found in Appendix F. This alternative is the most expensive alternative. The post-conditions flow rate in Midas Creek would be less than the FEMA flow rates, and there would be fewer culvert and channel improvement projects than other alternatives.

Alternative 6 – Large Storm Drain Pipe Along 11400 South to the Jordan River

The improvements associated with Alternative 6 could be combined with a different detention requirement. As stated in Chapter 5, there are several channel capacity deficiencies at approximately 1200 West between 11000 South and 11400 South. Improvements to the channel in that area would be difficult to construct because there is no access to the channel, and the County would be required to coordinate with several property owners to purchase permanent or temporary construction easements. To avoid the coordination with the property owners, the County could construct a pipeline along 11400 South. The pipeline would start just downstream of 1300 West and discharge to the Jordan River (approximately 2000 feet), as shown on Figure 6-6

This alternative is a stand-alone alternative that could be combined with any other alternative. Depending on which alternative is selected, the pipe size will range from 78 to 90-inch in diameter, and the cost will range between $3.0 to $3.8 million. The detailed cost estimate can be found in Appendix F. This alternative will negate the need to improve the Midas Creek channel between 1200 West and the Jordan River if there are property owners in that area who are unwilling to grant access, easements or permission to work on the Midas Creek channel in that area.

SUMMARY

Table 6-3 summarizes the costs for each of the alternatives discussed previously.

Table 6-3
Alternative Conceptual Cost Estimate Summary

Alternative	Construction Cost	Engineering, Legal, Administration, ROW Acquisition, & Contingency	Total Cost[1]
Alternative 1	$3,900,000	$1,800,000	$5,700,000
Alternative 2	$10,500,000	$4,800,000	$15,300,000
Alternative 3	$4,200,000	$1,900,000	$6,100,000
Alternative 4	$6,400,000	$2,900,000	$9,300,000
Alternative 5	$11,400,000	$5,200,00	$16,600,00
Alternative 6	$2,600,000 – $3,300,000	$400,000 - $500,000	$3,000,000 – $3,800,000

[1] The total cost does not include easement costs for the channel improvements at approximately 1200 West between 11000 South and 11400 South.

As can be seen from Table 6-3, the lowest cost alternative is Alternative 1. However, as discussed in previously, Alternative 1 includes significant costs for developers to construct retention basins and pump stations, and places undue burden on Cities and the County to maintain those retention facilities and pump stations. Because of those reasons, Alternative 1 is not the recommended alternative. Alternative 3 has the second lowest cost estimate to improve Midas Creek.

RECOMMENDATIONS

Alternative 3 is the Recommended Alternative to resolve capacity deficiencies – Based on analysis discussed in this report, and after reviewing the alternatives with representatives from Salt Lake County, Herriman City, Riverton City, and South Jordan City, it is recommended that all future development that discharges to Midas Creek or Butterfield Creek detain peak flows to 0.02 cfs/ac during the 100-year design event. This alternative has the second the lowest cost associated with improving Midas Creek. It allows development to continue to discharge to Midas Creek at pre-development discharge rates, which is consistent with the State of Utah requirements discussed previously. It also keeps the peak flow rate in Midas Creek below the FEMA preliminary flow rates, which will not increase the flood potential on Midas Creek identified on the FEMA preliminary floodplain maps.

It is important to note that the discharge limitation of 0.02 cfs/ac applies to the entire drainage area for Midas Creek. Development close to the downstream end of the Midas Creek will still need to limit the discharge rate to a maximum of 0.02 cfs/ac. Additionally, we recommend that culverts be installed as a single span culvert and not as a multiple barrel culvert that has the potential to capture debris and trash and is more likely to plug and cause flooding.

Herriman City has already adopted the standard in their Storm Drain Master Plan and requires new developments to discharge at a peak rate of 0.02 cfs/ac. The other Cities and the County will need to modify their development standards and require future development to provide local retention facilities that also manage runoff from any new streets. Any future development in the Midas Creek Drainage Basin will need to detain storm water runoff from a 100-year design storm to a peak value of 0.02 cfs/ac. The Midas Creek and Butterfield Creek drainage areas are identified on Figures 1-1 and 4-1.

Based on field reconnaissance performed as part of this study, some problems and deficiencies not related to capacity were discovered. Those issues are identified in Chapter 2. Recommendations to address those problems are provided below.

1. Monitor areas where the creek channel has been armored with rounded rock riprap. Rounded riprap has a high potential to fail as it can easily be pushed downstream by the velocity of flowing water. If the armoring fails, those areas should be repaired as needed. It was assumed that those repairs would be funded by private property owners adjacent to the creek.
2. Consider charging a fee for Salt Lake County Flood Control Permits for projects that include the installation of riprap or other significant channel improvements. The fee could be used to pay for more County oversight during construction. This could allow more quality control and reduce the potential for rounded or undersized riprap from being installed or avoid other potential problems that could fail during a significant runoff event.
3. Coordinate and work with private property owners that have constructed fences across the creek channel to have the fencing that is obstructing flow in the creek channel removed.
4. Monitor sections of the creek channel that are experiencing bank erosion and lateral channel migration. The bank erosion is not critical in most areas unless it is occurring near structures

or buried utilities. Install channel armoring as needed to protect existing utilities or infrastructure. Continue to require developers to install channel armoring adjacent to new developments as they occur so that the future structures can be protected.

5. There is an uncertified levee on the south side of the Midas Creek channel between 2700 West and USLC. Because the levee is not accredited by FEMA, the preliminary FIRMs include a Zone AE Special Flood Hazard Area (SFHA) along the south side of Midas Creek that surrounds several houses in a recently constructed development. The preliminary floodplain is based on LiDAR data collected in 2013-2014 when the property south of Midas Creek was undeveloped. Since that time fill has been placed on the property to facilitate development in the area. Survey of the fill was collected in 2021 and incorporated into the FEMA preliminary HEC-RAS model. The results from the updated HEC-RAS model show that the houses constructed as part of new development are above the Base Flood Elevations (BFE). Additionally, the houses to the south of the Creek in the area would be out of the floodplain if a LOMR is obtained from FEMA. Salt Lake County is in the process of obtaining a LOMR from FEMA to revise the floodplain in the area with the uncertified levee.

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