VOLUME 1 - REPORT

SOUTHWEST CANAL AND CREEK STUDY

Prepared for:

SALT LAKE COUNTY

March 2020

Prepared by:

BOWEN COLLINS & ASSOCIATES

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CHAPTER 1
INTRODUCTION

BACKGROUND INFORMATION

The original Southwest Canal and Creek Study was completed in 2002 (2002 SWCCS). The primary purpose of the 2002 SWCC Study 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, officials from Herriman City and Riverton City requested that the County update 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 first phase of the updated SWCCS, which includes a capacity evaluation of Rose Creek considering recent and planned development and identifying needed improvements to Rose Creek to safely manage storm water. Additional analyses and reports of the other creeks from the SWCCS will be completed in the future.

ROSE CREEK

Rose Creek is an ephemeral stream that only flows in response to storm events. It extends from Rose Canyon in the Oquirrh Mountains to the Jordan River at approximately 14200 South. Runoff collects in Rose Canyon and is conveyed along a well-defined channel to Mountain View Corridor (MVC) at approximately 4800 West. East of MVC, much of the Rose Creek Channel has been relocated or modified to facilitate development. Rose Creek is the major outfall for storm water runoff from portions of Herriman City, Riverton City and Bluffdale City.

HISTORY

Four irrigation canals were constructed to convey water diverted out of the Jordan River to farmland on the west side of the Salt Lake Valley. Those canals, from west to east were: the Provo Reservoir Canal (now known as the Welby Jacob Canal), the Utah Lake Distributing Canal, the Utah and Salt Lake Canal, and the South Jordan Canal. Irrigated farmland was established between the Provo Reservoir Canal and the Jordan River. West of the Provo Reservoir Canal non-irrigated farmland was established. Farming activities and irrigation practices resulted in some sections of Rose Creek becoming inactive.

When development pressure began to occur in Herriman, Bluffdale, and Riverton in the mid-1990s, Salt Lake County sponsored engineering and construction work to re-establish Rose Creek as a major conveyance facility for storm water runoff. At that time, Rose Creek had no active channel east of the Utah and Salt Lake Canal. In the late 1990s, Rose Creek was re-established between the Utah and Salt Lake Canal and the Jordan River. One of the key objectives of this master planning project will be to ensure that needed storm water management facilities are constructed so that extensive improvements are not required on the newer sections of the Rose Creek channel and associated bridges and culverts.

STUDY AREA

The study area for this project extends from the west municipal boundary of Herriman to the Jordan River as shown on Figure 1-1.

PURPOSE OF STUDY

The primary purpose of this study is to identify improvements needed to manage storm water runoff conveyed in Rose Creek.

MAJOR STUDY TASKS

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

- Develop a Hydrologic Model of Rose Creek
- Develop a Hydraulic Model of Rose Creek
- Evaluate Alternatives to Limit Discharge to Rose Creek
- Review Alternatives with Rose Creek Stakeholders
- Recommended Improvements Based on Input from Rose Creek Stakeholders
- Write 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 conditions of the Rose Creek 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 data collection, inventory of structures and the general existing conditions of the study reach of Rose Creek.

DATA COLLECTION

This section discusses the data collection and analysis associated with topography, survey and field reconnaissance. The primary goals of this task were to compile a detailed inventory of the structures on Rose Creek and to collect information needed to develop a hydraulic model of the canal.

Topography and Aerial Photography

Topographic and aerial photographic mapping along Rose 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 section of Rose Creek were field surveyed at about 500-foot intervals through the open channel section of the canal. Because Rose Creek is ephemeral, the survey took place when the creek was not flowing. Survey data was also collected for three canal dump-out structures that discharge into Rose Creek at where the canals cross the creek. Structures that were surveyed included:

- Dump-out structures that discharge into Rose Creek from the canals
- Bridges and culverts
- Inline structures

INVENTORY OF STRUCTURES

This section presents an inventory of the existing structures along the study reach of Rose Creek. The inventory of structures is included on Figure 2-1.

Bridge, Culvert and Drop Structures

There are 32 bridges and culverts along Rose Creek. There are also 11 inline grade control structures. The survey for those structures was used to develop the hydraulic model as described in Chapter 5.

Dump-out Structures

There are three storm water overflow/dump-out structures that discharge from canals to Rose Creek. The overflow structures include a gate to drain the canal, and a weir to overflow into the storm drain system, as shown on Photo 2-1. Table 2-1 identifies the locations of the 3 existing storm drain overflow/dump-out structures.

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	1400 West

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

Photo 2-1
Overflow/Dump-Out Structure at Utah and Salt Lake Canal

SUMMARY OF GENERAL OBSERVED RISKS

A visual assessment of Rose Creek was completed. The purpose of the visual assessment was to observe general conditions of the creek and potential hazards. This section summarizes the observations noted during the visual assessment. The deficiencies are identified on Figure 2-1.

General Observed Risks

The visual assessment took place in early 2019. The following hazards were observed in the Rose Creek Channel.

- Fences that cross the channel
- Uncertifiable levees
- Potential unpermitted culverts
- Eroded channel banks
- Use of non-angular (rounded) riprap for channel armoring

Each of those potential hazards are discussed below.

Fences that Cross the Channel

There are several locations were fences cross the Rose 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.

Photo 2-2
Fence Crossing Rose Creek Upstream of Spring Canyon Drive

Uncertifiable Levees

There are locations where there are constructed earthen levees along Rose Creek that probably cannot be certified to meet minimum FEMA design criteria due to a lack of freeboard. If FEMA updates the Flood Insurance Rates Maps (FIRMs) upstream of the Utah Lake Distribution Canal, the floodplains adjacent to uncertified levees may be mapped as if the existing earthen levees do not exist, even if the existing channel has adequate capacity. The locations of the uncertified levees are identified below:

- Upstream of 4000 West adjacent to the South Hills Middle School
- Between 13400 South and 3600 West adjacent to the Riverton Walmart

Photo 2-3
Uncertified Levee upstream of 4000 West
adjacent to the South Hills Middle School

Potential Unpermitted Culverts

There are several small culverts in Herriman at approximately 6500 West that were likely constructed without getting needed permits from the City, Salt Lake County, and the State of Utah. Those culverts restrict the flow in the stream channel. However, the resulting floodplain in the vicinity of those unpermitted culverts appears to be confined within the channel banks and does not appear to impact an insurable structure.

Eroded Banks

The banks of Rose Creek in some areas have experienced erosion and the bank slope is nearly vertical. However, the vertical banks and the associated bank instability in those areas are not currently adjacent to urban development. An example of the erosion with a near vertical bank is at approximately 3250 West on Rose Creek near the Riverton City Fishing Pond.

Photo 2-4
Eroded Banks on Rose Creek at approximately 3250 West

Rounded Riprap

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

Photo 2-5
Rounded riprap upstream of Spring Canyon Drive (6090 West)

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, effort was made to achieve results consistent with the existing studies, while preserving the elements of analysis based on the most current data. 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	In Process	Herriman City	Bowen Collins and Associates	Herriman City
Bluffdale Storm Water Master Plan	2017	Bluffdale City	Horrocks Engineers & Aquaveo	Bluffdale City
Preliminary FEMA Floodplain Maps and Models	November 2017	Salt Lake County Flood Control	AECOM	Rose Creek
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 storm drain system 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 Rose 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 Rose Creek drainage basin. The methods used to estimate the capacity of Rose Creek and its related hydraulic structures is discussed in Chapter 5.

PREVIOUS MODELS

An ASSA model was developed as part of a separate study for that included the preparation of a Storm Drain Master for Herriman City (in 2019). That ASSA model had smaller subbasins, included more storm water detention facilities, included pipe and more open channel data, and was more detailed that the 2002 SWWCS model that was developed using the HEC-HMS modeling software. Since a significant portion of the Rose Creek drainage area had been modeled using the ASSA software, the decision was made to expand the Herriman ASSA model to include the remaining portion of the Rose Creek drainage area, including subbasins in Riverton and Bluffdale. The ASSA software utilizes the same procedures and routines to simulate the rainfall-runoff process as those used by the HEC-HMS software. The Herriman Storm Drain Master Plan model was calibrated to produce unit runoff values that are similar to those computed during the 2002 SWCCS.

The methodology used to develop the hydrologic model parameters for the additional subbasins in Bluffdale and Riverton were 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 Model

DRAINAGE BASIN AND SUBBASIN DELINEATION

The Rose Creek Drainage basins boundaries and related subbasin boundaries were delineated based on storm drain GIS inventory data provided by Riverton City, Bluffdale 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 in each subbasin. The Rose 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.

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 flows from the 3-hour design storm are severely underestimated over Hydrologic Soil Group (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. Table 4-1 shows the Curve Numbers used in this study based on soil type and as assumed vegetative ground cover for developed areas.

Table 4-1
SCS Curve Number

Soil Type	Curve Number*
A	39
B	61
C	74
D	80

* From Table 2-2 in TR-55 "Open Space – Good Condition Grass Cover > 75%"

Area

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

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 data provided by Salt Lake County, Herriman City, Riverton City, and Bluffdale City. Each land use type was analyzed based on the aerial photography and the estimated impervious area was recorded. The amount of directly-connected impervious area was also 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 Table 4-2 to estimate the directly-impervious area for both existing and full build-out conditions.

Table 4-2
Average Imperviousness Based on Land Use

General Plan Land Use Type	Directly Connected Imperviousness (Percent)
Business/Commercial	85%
Church	75%
Industrial	72%
High Density Over 16 Units	70%
Medium Density Residential 4-16 Units	25%-50%
Low Density Residential 2-4 Units	20%
Low Density Residential 0-3 Units	15%
Open Space	0%

Lag Time

Snyder's equation, or Worksheet 3 in TR-55, was initially used to estimate the lag time for each subbasin. The lag time was further adjusted for some subbasins during the calibration process to adjust the peak runoff to be within, or closer to, the calibration target range described in the following sections.

DESIGN STORM PARAMETERS

The design storm used for the analysis of Rose Creek was the same design storm used in the 2002 SWCCS and the Herriman Storm Drain Master Plan: a 100-year, 3-hour storm. This design storm was selected by the County is the design standard that will be used to identify deficiencies and size needed channel improvements. A design storm has a specified depth and temporal precipitation distribution. Design storms were 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
- Storm Distribution: Modified Farmer – Fletcher
- Recurrence Interval: 100-year Storm
- Storm Depth (From NOAA Atlas 14):

  100-Year: 1.97 inches

Areal Reduction of Rainfall

Intense summer cloudburst events typically move across the Salt Lake Valley and are rarely distributed over a large area. Precipitation depth reduction factors for the larger drainage basins were utilized in the hydrologic analysis. 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.

These 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 (1983). That report recommends the following precipitation depth-area relationship for a thunderstorm of 3-hour duration, with area in square miles:

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

This relationship is based on data from *Project Cloudburst,* a study completed by the U.S. Army Corps of Engineers in April 1979. That study involved collection of data from a network of rain gages in Salt Lake City and vicinity covering an area of roughly 350 square miles.

The given depth-area relationship was used to estimate areal reduction factors for concentration points along Rose 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 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.

Table 4-3
Areal Reduction Factors for Rose Creek
Existing and Proposed Conditions

Location - Immediately Downstream of:	Storm Cell Area (sq mi)	Areal Reduction Factor
Welby Jacob Canal	53.0	0.7
Utah Lake Distributing Canal	60.4	0.7
Utah & Salt Lake Canal	66.3	0.7
South Jordan Canal	71.5	0.7

DETENTION BASINS

The Rose Creek drainage area is largely developed and includes multiple regional and local storm drain detention facilities. City's provided as-built drawings or design reports for most of the larger detention facilities. For detention basins where as-built drawings or design reports were not available, stage-storage curves were developed using 2013-2014 LiDAR data, and outlet structure data were collected from GIS databases or field visits.

Future Detention Basins

The collective assumption was made that undeveloped areas in the Rose Creek drainage basin would detain storm water runoff and discharge at a peak rate of 0.2 cfs/ac, as defined in the 2002 SWCCS. Detention basins were added to the future conditions model that limited discharge in undeveloped areas to 0.2 cfs/ac.

MODEL CALIBRATION

The final step in the hydrologic modeling process was model calibration. In general, calibration of a hydrologic model of an urban area 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 streamflow gage on Rose Creek just upstream of its confluence with the Jordan River since 2015, there is not enough or adequate flow data on Rose Creek or the City's urban drainage systems that could be used for model calibration.

Calibration Target Range

The rainfall-runoff model for the study area generally produces peak runoff rates that range from 0.25 to 0.5 cfs/acre runoff for quarter-acre residential subdivision lots. Those runoff values are consistent with the peak runoff values identified in the Water-Resources Investigations Report 89-4095 entitled "Peak-Flow Characteristics of Small Urban Drainages along the Wasatch Front, Utah" from the U.S. Geological Survey published in 1989.

Model Calibration

Peak runoff values for each drainage subbasin were reviewed and compared to the calibration target range. A target peak runoff value of 0.25 to 0.5 cfs/acre was used for residential subbasins. Additionally, subbasin runoff generated by the computer model were typically less than the results obtained using the Rational Method, which is generally considered to produce conservative (high) estimates of flows.

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 Bluffdale, Herriman and Riverton are 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 Bluffdale, 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 Rose Creek is the low point of the drainage system, most of the storm water runoff in the streets will still be conveyed to Rose Creek, even though it may follow the same path as the storm drain pipe network. Because Rose Creek is low point of the drainage system, and because the purpose of this study was to analyze Rose Creek, the conservative assumption was made that all runoff from the 100-year design storm will be conveyed to Rose Creek.

RESULTS & CONCLUSIONS

The estimated peak flow rates in Rose Creek from the hydrologic model are included in Table 4-4. Also included in Table 4-4 are the runoff values from the 2002 SWCCS.

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

Location	City	Preliminary FEMA Peak Discharge	2002 Southwest Canal and Creek Study (Full Build-out Conditions)[1]	Existing Conditions	Full Build-Out or Future Conditions[1]
Mouth of Rose Canyon	Herriman	-	155	73	73
The Cove Detention Basin	Herriman	-	155	179	179
Blayde Drive	Herriman	-	155	227	227
6400 West	Herriman	-	420	262	262
Mirabella Drive	Herriman	-	485	323	323
Rosecrest Road	Herriman	-	305	176	176
Morning Cloak Way	Riverton	-	305	272	272
Mountain View Corridor	Riverton	-	380	312	312
Welby Jacob Canal[2]	Riverton	-	500	350	505
Bangerter Hwy[2]	Riverton	-	520	390	570
Chamonix Park[2]	Riverton	-	520	420	600
Utah Lake Distribution[2]	Riverton	550	575	470	650
Bangerter Hwy[2]	Bluffdale	550	575	490	650
Utah and Salt Lake Canal[2]	Bluffdale	580	585	530	690
2200 West[2]	Bluffdale	580	585	535	690
Redwood Road[2]	Bluffdale	580	585	540	690
South Jordan Canal[2]	Bluffdale	580	585	560	710
1300 West[2]	Bluffdale	580	585	560	710
Blue Quill Drive[2]	Bluffdale	580	585	560	710

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

There are two observations that can be made from Table 4-4.

1. The existing conditions discharge rates are identified in this study are slightly lower than the build-out peak discharge rates identified in the 2002 SWCCS.
2. The projected peak flow rates in Rose Creek for the full built-out conditions in this study are much higher than the build-out peak flow rates identified in the 2002 SWCCS.

The reasons for the increase full build-out peak discharge rates are listed in the following subsections.

Additional Drainage Area into Rose Creek - The hydrologic model developed as part of the 2002 SWCCS was developed at a regional scale. Drainage basin and subbasin delineations were made based on the best available data at the time. Since that time, the previously anticipated development patterns in Herriman, Riverton and Bluffdale have changed significantly. As a result, there are large areas in those Cities which were previously designated to drain to Midas

Creek that now drain to Rose Creek. The total additional area discharging into Rose Creek is 819 acres, as can be seen on Figure 4-2.

Additional Development – The 2002 SWCCS generally assumed that developable areas would detain storm water runoff from the 100-yr storm to a maximum discharge rate of 0.2 cfs per acre (cfs/ac). The remainder of the drainage area would discharge at the pre-development flow rate (generally between 0.02-0.05 cfs/ac for the 100-yr storm). As stated in the introduction to this report, the collective population of Riverton, Herriman and Bluffdale has almost tripled in the past 20 years, and the anticipated development patterns in those cities have changed significantly. There are areas in those cities that have developed that were assumed would not develop in the 2002 SWCCS. Those areas are discharging at 0.2 cfs/ac to Rose Creek when they were originally anticipated to discharge at only 0.02-0.05 cfs/ac in the 2002 SWCCS.

Runoff from South Herriman - The 2002 SWCCS indicated that the majority of South Herriman was going to discharge storm water runoff into Rose Creek via a dumpout structure at the Utah Lake Distributing Canal crossing. However, due to the annexation of South Herriman, that area is now planned to discharge runoff into Rose Creek just upstream of the Welby Jacobs Canal. Because the South Herriman area was not originally intended to discharge into Rose Creek so far upstream, Rose Creek has very little capacity for South Herriman's runoff at the Welby Jacob Canal. To account for the limited capacity in Rose Creek, all area discharging from South Herriman has been detaining its peak flow rates to 0.02 cfs/ac. This will allow South Herriman to discharge to Rose Creek upstream of the Welby Jacob Canal without exceeding the capacity in the Rose Creek Channel defined in the 2002 SWCCS.

CHAPTER 5
HYDRAULIC ANALYSES

A HEC-RAS hydraulic computer model of the reach of Rose Creek that extends from the west boundary of Herriman City to the Jordan River was developed utilizing topographic data, survey data, 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. Geo-HECRAS was utilized to create a HEC-RAS geometry file. The purpose of this chapter is to describe the process used to develop the hydraulic model and to summarize the modeling results associated with the hydraulic analyses.

MODEL DEVELOPMENT

This section outlines the general methodology and approach used to complete the hydraulic modeling tasks for this project.

Basic Information

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

Topographic Data

Survey cross sections of the study reach of Rose Creek and 2013-14 LiDAR data from AGRC were used in conjunction with Geo-HECRAS to develop 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 canal.

Downstream Boundary Conditions

Rose Creek discharges to the Jordan River. The base flood (100-year flood) elevation at the Rose Creek confluence with the Jordan River (4370 feet) was read from the current-effective FEMA flood insurance rate map for the Jordan River and used as the downstream boundary condition for the Rose Creek model.

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 0.060, and a value of 0.040 was used for the channel. Those Manning's "n" values are within an acceptable range that reflect the channel conditions and are close to the values used in the 2002 SWCCS.

Stream Layout and Cross-section Locations

The Rose Creek centerline location was 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 top of bank, toe of channel, 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 Rose Creek. The model included 270 cross sections and 45 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 Rose Creek, 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 Rose Creek has been included in Appendix A of this report.

The water surface elevations and floodplain boundary data from a preliminary FEMA Flood Insurance Study (FIS) of Rose Creek were also compared to the results of this study. Both the water surface elevations and the floodplain boundaries from the HEC-RAS model developed as part of this are similar to the preliminary FEMA FIS study results for Rose Creek. The 100-year floodplain boundaries from the HEC-RAS model developed as part of this study are compared to those developed as part of the preliminary FEMA FIS are shown on Figure 5-1. It is important to this study's floodplain has not gone through the floodplain quality control process. The floodplain represents the raw model output, and was only developed to compare to the FEMA preliminary floodplain.

A stream gage was installed by Salt Lake County on Rose Creek in 2015. However, there is not enough data available from that gage to provide calibration data on the Rose Creek model. In addition, the length of the gate record is not long enough to perform meaningful a flow frequency analysis.

FREEBOARD

The recommended freeboard on Rose Creek is a minimum of two feet. Areas with more than two feet of freeboard were not identified as deficient on the figures. If an area had between zero and two feet of freeboard (i.e. is it not flooding) it is identified on the figures, but does not include a recommended project to increase the freeboard. If bank of Rose Creek is overtopping, the area is identified as deficient on the figures and includes a recommended project. Culverts and Bridges were considered deficient if they overtopped, or if they restricted flow in the channel and caused an upstream bank deficiency.

MODEL RESULTS

The hydraulic model was run with the existing and future conditions peak flow rates identified in the Chapter 4. The results of those runs are included on Figures 5-2 and 5-3. Observations about the information presented on Figures 5-2 and 5-3 is presented below.

Flow Rate Associated with Existing Conditions – Figure 5-2 identifies the freeboard and culvert deficiencies on Rose Creek for the flow rates associated with existing development conditions. There are 5 existing culvert capacity deficiencies located at: the Welby Jacobs Canal; 3160 West; and three culverts at 2700 West. These culvert deficiencies are discussed below. Only 4 of the culvert deficiencies are identified on Figure 5-2 for the reasons listed below.

- **UDOT Culvert under the Bangerter Highway at 2700 West** – This culvert capacity deficiency is not identified on Figure 5-2. The UDOT culvert can pass the 100-year flow, but only if the culvert surcharges 2 feet above the top of the culvert opening. The back water from the culvert causes flooding at the 2 upstream culverts at 2700 West. However, the cost to upsize the UDOT culvert across Bangerter would be extremely expensive. A more economical solution would be to install a concrete lined channel between the culverts at 2700 West. Because of the limited Right of Way along Rose Creek in this area, the concrete channel will need to have vertical floodwalls. That is the proposed project identified on the figures.
- **2700 West and 13760 South** – The culvert at 2700 West and 13760 South had not been constructed when the 2002 SWCCS was completed, and therefore was not identified in the 2002 SWCCS as a deficiency. The deficiency appears to be caused by two factors: backwater conditions from the limited capacity of the UDOT culvert crossing Bangerter (see previous bullet point), and the culvert is undersized. The culvert will need to upsized, in addition to constructing the concrete lined channel described in the previous bullet point.
- **2700 West and 13700 South** – The culvert at 2700 West and 13700 South was replaced within the past 10 years by Salt Lake County. Though the culvert is large enough to pass the 100-year flow, the top of the culvert is about 1 foot above the natural ground. To pass the 100-year flow, the culvert would need to surcharge approximately 6-inches over the top of the culvert. There would be approximately 1.5 feet of water overtopping the channel before the culvert could convey that much flow. The bank overtopping would flood nearby properties. The culvert will need to be replaced with a similar sized culvert, with a lower invert elevation.
- **Welby Jacobs Canal Crossing at 3160 West** - The culvert capacity deficiency at the Welby Jacobs Canal crossing at 3160 West was identified in the 2002 SWCCS. Replacing the undersized culvert under the canal is in the County's master plan of needed improvements.

There are also a few channel capacity deficiencies for existing development conditions at other various locations identified on Figure 5-2. Aside from the previously mentioned deficiencies, the majority of Rose Creek channel has capacity to safely convey the 100-year discharge associated with the existing development conditions.

The model was also run with the 2002 SWCCS peak discharge rates and the results are similar to the model run with flow rates associated with existing conditions.

Flow Rate Associated with Future Conditions – Figure 5-3 identifies the freeboard and culvert deficiencies on Rose, based on future conditions flow rates, if future development detains to 0.2 cfs/ac. There will be 6 culvert deficiencies at the Welby Jacobs Canal crossing, Millennium Lane, 3160 West, three at 2700 West, and 1300 West. The deficiencies at Welby Jacobs Canal, 3160 West, and three at 2700 West are discussed in the existing conditions sub-section. Below is a description of the new deficiencies associated with future conditions analysis.

- **Millennium Lane** – The culvert deficiency at Millennium Lane is due to the culvert being undersized. The culvert will need to be upsized to mitigate flooding potential in the area. This culvert has been constructed within the past 10 years.
- **1300 West -** The culvert deficiency at 1300 West would be the result of increased peak flows in Rose Creek (see discussion in Chapter 4). It would need to be upsized to pass the future conditions flow rates.

It is important to note that the two culvert projects at Millennium Land and 1300 West would not be required if the peak discharge in Rose Creek was limited to the flow rates identified in the 2002 SWCCS. Both of these projects would be costly and difficult to construct. Additionally, there would also be several additional channel capacity deficiencies if the flow rate is Rose Creek is not limited to flow rates identified in the 2002 SWCCS.

CONCLUSION

If the future development continues to discharge to Rose Creek at 0.2 cfs/ac, additional projects not anticipated in the 2002 SWCCS will be required to safely convey the 100-year flow to the Jordan River. To avoid the additional projects, several alternatives were analyzed as described in the next chapter.

CHAPTER 6
ALTERNATIVES ANALYSIS AND RECOMMENDATIONS

INTRODUCTION

The hydrologic and hydraulic analyses performed as part of this project identified a number of capacity deficiencies. Some are existing culvert and channel capacity deficiencies that will get worse if additional development is allowed to release storm water runoff into Rose Creek at a rate of 0.2 cfs/acre. Some additional capacity deficiencies will be experienced if the remaining developable land in the Rose Creek drainage basin is allowed to discharge storm water into Rose Creek at the previously-allowed rate of 0.2 cfs. This storm water release rate includes runoff from public streets, not just from private property.

As stated in Chapter 4 and shown in Table 4-4, the estimated 100-year discharge rates in Rose Creek east of the Utah and Salt Lake Canal for existing development conditions is about the same magnitude as the full buildout discharges estimated in the 2002 SWWCS. Six project alternatives were evaluated that, if implemented, would significantly reduce or avoid costly improvement projects to increase the capacity of the Rose Creek channel and its associated bridges and culverts associated with discharges that are larger than originally planned. The purpose of this chapter is to summarize the analyses, conclusions, and cost estimates associated with the alternatives analysis to resolve the projected capacity deficiencies and to identify other maintenance and administrative needs to resolve problems that were observed in the field.

ALTERNATIVES TO RESOLVING CAPACITY DEFICIENCIES

The following alternatives were analyzed in an effort to identify the most cost-effective means to mitigate capacity deficiencies and to preserve capacity needed in Rose Creek to accept runoff from future development.

Alternative 1 – Future Development Retains Storm Water Runoff On-Site
Alternative 2 – Future Development Discharges at 0.2 cfs/ac to Rose Creek
Alternative 3 – Future Development Discharges at 0.02 cfs/ac to Rose Creek
Alternative 4 – Regional In-Stream Detention Facility
Alternative 5 – Large Storm Drain Pipe Along 13800 South to Jordan River
Alternative 6 – Large Storm Drain Pipe Along 13800 South to 2700 West.

The future conditions hydrologic model described in Chapter 4 was copied and modified to estimate the peak storm water discharges in Rose Creek for each of the six potential improvement alternatives. Flow rates computed by the revised hydrologic models at key locations on Rose Creek for each of the alternatives are included in Table 6-1. The peak flows for each alternative were then entered into the hydraulic model described in Chapter 5. The capacity deficiencies associated with each alternative were identified based on the model results. A description of each of the alternatives and the conceptual cost estimate is presented in the following sub-sections.

Table 6-1
100-year Peak Flows in Rose Creek

Location	City	HEC-RAS Cross Section Station	2002 Southwest Canal and Creek Study (Full Build-out Conditions)[1]	Existing Conditions Or 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 –Inline Detention Facility (cfs)	Alternative 5 – 13800 South Storm Drain to Jordan River (cfs)	Alternative 6 – 13800 South Storm Drain to 2700 West (cfs)
Mouth of Rose Canyon	Herriman	46625	155	73	73	73	73	73	73
The Cove Detention Basin	Herriman	45333	155	179	179	179	179	179	179
Blayde Drive	Herriman	43089	155	227	227	227	227	227	227
6400 West	Herriman	41391	420	262	262	262	262	262	262
Mirabella Drive	Herriman	38652	485	323	323	323	323	323	323
Rosecrest Road	Herriman	35901	305	176	176	176	176	176	176
Morning Cloak Way	Riverton	31270	305	272	272	272	272	272	272
Mountain View Corridor	Riverton	27771	380	312	312	312	312	312	312
Welby Jacob Canal[2]	Riverton	24261	500	350	505	450	60	430	430
Bangerter Hwy[2]	Riverton	21129	520	390	570	510	250	490	490
Chamonix Park[2]	Riverton	16237	520	420	600	540	330	540	600
Utah Lake Distribution[2]	Riverton	15995	575	470	650	585	365	575	650

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Table 6-1 (continued)
100-year Peak Flows in Rose Creek (cfs)

Location	City	HEC-RAS Cross Section Station	2002 Southwest Canal and Creek Study (Full Build-out Conditions)[1]	Existing Conditions Or 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 –Inline Detention Facility (cfs)	Alternative 5 – 13800 South Storm Drain to Jordan River (cfs)	Alternative 6 – 13800 South Storm Drain to 2700 West (cfs)
Bangerter Hwy[2]	Bluffdale	11175	575	490	650	600	450	575	650
Utah and Salt Lake Canal[2]	Bluffdale	9998	585	530	690	635	530	580	690
2200 West[2]	Bluffdale	8539	585	535	690	635	540	580	690
Redwood Road[2]	Bluffdale	4718	585	540	690	635	540	585	690
South Jordan Canal[2]	Bluffdale	3837	585	560	710	650	585	595	710
1300 West[2]	Bluffdale	3022	585	560	710	650	585	595	710
Blue Quill Drive[2]	Bluffdale	1342	585	560	710	650	585	595	710

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

Alternative 1 assumes that all future development in the Rose Creek drainage area will be required retain all storm water runoff on-site until it infiltrates into to the ground or until it could be pumped into the storm drain system after the peak flow in Rose Creek has passed. If this alternative is implemented, the existing 100-year peak flow in Rose Creek in the future will not increase. The recommended improvements to Rose 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 Rose Creek to the Jordan River. Figures 5-2 and 6-1 identify the deficiencies, improvements and conceptual cost estimate associated with this alternative.

The conceptual cost associated with the improvements to Rose Creek would be $4.1 million. The detailed cost estimate can be found in Appendix B. These costs do not include the costs of the retention facilities that will be required to ensure no runoff from future development will reach Rose Creek. It was assumed that each development will retain runoff. This retention requirement would also need to apply to any new streets.

This alternative provides very little flexibility for the Cities. Rose Creek is low point of the storm drain system in the valley, and not allowing storm water runoff to discharge to Rose Creek would be a burden on the Cities. It would require many small local retention basins or multiple large regional retention facilities and possibly some pump stations to discharge storm water to Rose Creek after the peak flow has passed.

Alternative 2 – Future Development Discharges at 0.2 cfs/ac to Rose Creek

Though this alternative has been discussed in previous chapters of this report, it has been added here so it can be compared to the other alternatives. This alternative includes allowing future development to discharge to Rose Creek at a rate of 0.2 cfs/ac. Figures 5-3 and 6-2 identify the deficiencies, improvements and conceptual cost estimate associated with this alternative.

The conceptual cost associated with the improvements to Rose Creek would be $5.8 million. The detailed cost estimate can be found in Appendix B.

This alternative includes costs for the County that were not originally anticipated in the 2002 SWCCS. It would require additional projects on Rose Creek to safely convey the 100-year flow rate, as described in Chapter 5.

Alternative 3 – Future Development Discharges at 0.02 cfs/ac to Rose Creek

This alternative includes allowing future development to discharge to Rose Creek at a rate of 0.02 cfs/ac. This discharge rate is similar to the pre-development peak flow rate and would closely match the pre-development hydrology. Figures 6-3A and 6-3B identify the deficiencies, improvements and conceptual cost estimate associated with this alternative.

The conceptual cost associated with the capacity-related improvements to Rose Creek would be $5.0 million. The detailed cost estimate can be found in Appendix B.

This option would provide the needed flexibility for cities to continue to discharge to Rose Creek, but would limit the peak discharge in Rose Creek so there are fewer future projects to improve the capacity of Rose Creek.

Alternative 4 – Regional In-Stream Detention Facility

This alternative includes constructing a large in-stream regional detention facility on Rose Creek immediately upstream of the Welby Jacob Canal. The deficiencies and recommended Rose Creek channel improvements associated with this alterative are identified on Figure 6-4A. The detention basin footprint would be approximately 30 acres and the required detention volume would be approximately 300 acre-feet (ac-ft), as shown on Figure 6-4B. The peak discharge rate from the detention basin would be approximately 60 cfs. It is important to remember that most of the property around Rose Creek has been developed. Therefore, there is very little open area for a large in-stream detention basin on Rose 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.

The conceptual cost associated with the improvements to Rose Creek would be $24.2 million. The detailed cost estimate can be found in Appendix B.

Alternative 5 – Large Storm Drain Pipe Along 13800 South to Jordan River

This alternative includes constructing a large storm drain facility along 13800 South from the Welby Jacobs canal to the Jordan River. The deficiencies and recommended Rose Creek channel improvements associated with this alterative are identified on Figure 6-5A. The conceptual alignment of the 13800 South pipeline is shown on Figures 6-5B. Overflow structures would be constructed on the Utah Lake Distributing Canal, Utah and Salt Lake Canal and South Jordan Canal that discharge to the 13800 South storm drain pipe. Future development would continue to detain peak flows to a maximum of 0.2 cfs/ac with this alternative.

The conceptual cost associated with the improvements to Rose Creek would be $9.6 million. The detailed cost estimate can be found in Appendix B.

Alternative 6 – Large Storm Drain Pipe Along 13800 South to 2700 West

This alternative is similar to Alternative 5, but the large storm drain facility along 13800 South would discharge back into Rose Creek at approximately 2700 West. The deficiencies and recommended Rose Creek channel improvements associated with this alterative are identified on Figure 6-6A. The conceptual alignment of the 13800 South pipeline is shown on Figure 6-6B. An overflow structure would be constructed on the Utah Lake Distributing Canal that would discharge to the 13800 South storm drain pipe. Future development would continue to detain peak flows to a maximum of 0.2 cfs/ac with this alternative.

The conceptual cost associated with the improvements to Rose Creek would be $7.7 million. The detailed cost estimate can be found in Appendix B.

SUMMARY

Table 6-2 summarizes the costs for each of the alternatives discussed previously.

Table 6-2
Alternative Conceptual Cost Estimate Summary

Alternative	Construction Cost	Engineering, Legal, Administration, ROW Acquisition, & Contingency	Total Cost
Alternative 1	$ 4,136,000	$ 620,400	$ 4,760,000
Alternative 2	$ 5,841,000	$ 876,150	$ 6,720,000
Alternative 3	$ 4,980,000	$ 747,000	$ 5,730,000
Alternative 4	$ 24,218,000	$ 3,632,700	$ 27,850,000
Alternative 5	$ 9,556,000	$ 1,433,400	$ 10,990,000
Alternative 6	$ 7,667,000	$ 1,150,050	$ 8,820,000

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 Herriman City, Riverton City, and Bluffdale City, it is recommended that the all future development that discharges to Rose Creek detain peak flows to 0.02 cfs/ac. This will require that all 3 cities 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 Rose Creek Drainage Basin will need to detain storm water runoff to a maximum of 0.02 cfs/ac. The Rose Creek Drainage area is 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. It is recommended that Salt Lake County consider charging a fee for Flood Control Permits for projects that include the installation of riprap and significant channel improvements. The fee should be used to pay for more County oversight during construction. This should allow more quality control and reduce the potential for rounded or undersized riprap from being installed 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. Earthen levees have been constructed at the tops of the creek banks in two areas: Near the Riverton Walmart and South Hills Middle School. It is recommended that County personnel coordinate with associated City representatives and private property owners to discuss the flood insurance impacts of levees that do not meet FEMA accreditation criteria and to develop a plan to address any needed improvements or to implement an accreditation program.

BOWEN COLLINS
& ASSOCIATES

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