IVINS CITY STORM DRAIN MASTER PLAN

APRIL 2024

NOTICE DRAFT

PREPARED FOR:

IVINS CITY UTAH

PREPARED BY:

BOWEN COLLINS & ASSOCIATES

TABLE OF CONTENTS

Page No.

LIST OF TABLES

LIST OF FIGURES

APPENDICES

SECTION 1 INTRODUCTION

1.1 BACKGROUND

The City of Ivins (City) most recently updated their Storm Drain Master Plan in 2016. Since that time, multiple storm drain infrastructure projects and new residential and commercial developments have been built. The City retained Bowen Collins & Associates (BC&A) to prepare a new Storm Drain Master Plan that accounts for these recent changes. The primary purpose of this Storm Drain Master Plan is to provide recommended improvements to resolve existing deficiencies and plan for future growth in the City's storm drain system based on the adopted General Plan.

This document is a working document. Some of the recommended improvements identified in this report are based on the assumption that development and/or potential annexation will occur in a certain manner. If future growth or development patterns change significantly from those assumed and documented in this report, the recommendations may need to be revised. The status of development should be reviewed at least every five years. This report and the associated recommendations should also be updated every five years.

1.2 SCOPE OF SERVICES

The general scope of this project involved a thorough analysis of the City's storm drain system and its ability to meet the present and future storm drain needs of the City's residents. As part of this project, BC&A completed the following tasks:

Task A: Land Use/Population Analysis. Review land use and population projection data provided by Ivins City to update existing and future conditions in the City's InfoSWMM hydraulic model.

Task B: Hydrologic/Hydraulic Criteria. Review rainfall depths for the hydrologic model for storms with a 10% and 1% probability of occurring in any given year (10-yr and 100-yr Storm). The Farmer Fletcher Storm distribution was used for master planning purposes to simulate a cloudburst type storm. If needed, provide recommendations to update hydrologic/hydraulic criteria.

Task C: Existing Condition Analysis. Modify the existing Ivins City InfoSWMM model by incorporating new facilities that have been constructed since the preparation of the previous storm drain master plan. Update the City's InfoSWMM hydrologic computer model based on land use conditions, using City zoning and land use information, and modifying subcatchment boundaries and parameters as needed. Insert detention basins with the associated stage storage curves. Use this model to review existing deficiencies with City personnel and develop conceptual solutions.

Task D: Build-Out Condition Analysis. Modify Existing Conditions Hydraulic model (Task C) for future growth based on the City's zoning and land use information.

Task E: Capital Facilities Planning. Propose Capital Facilities improvements that resolve existing deficiencies and allow for planned future growth, including cost estimates and a phasing plan for implementing these improvements. Prepare a draft storm drain master plan. Incorporate comments and finalize master plan report.

Task F: Impact Fee Facilities Plan. Develop an Impact Fee Facility Plan (IFFP) based on the capital improvements identified as part of Task E for this report. Prepare a draft IFFP report to be reviewed with City personnel. Incorporate comments and finalize IFFP report.

Task G: Impact Fee Analysis. Prepare an Impact Fee Analysis (IFA) based on the IFFP projects identified in Task F. Prepare a draft IFA report to be reviewed with City personnel. Incorporate comments and finalize IFA report.

Task H: User Fee Analysis. Prepare a User Fee Analysis based on operation and maintenance information provided by the City and on the costs developed as part of the Capital Facilities Plan. Prepare a draft User Fee Analysis report to be reviewed with City personnel. Incorporate comments and finalize report.

This report is prepared as part of Task E.

1.3 AUTHORIZATION

Ivins City contracted the services of BC&A to prepare this Storm Drain Master Plan in August 2022.

1.3.1 PROJECT STAFF

The project work was performed by the BC&A team members listed below. Team members' roles on the project are also listed. The project was completed in BC&A's St. George, Utah office. Questions may be addressed to Todd Olsen, Project Manager at (435) 656-3299.

Todd Olsen	Principal-In-Charge/Project Manager
Cody Moultrie	Project Engineer
Mike Hilbert	Word Processing

1.3.2 IVINS CITY STAFF

City staff also worked closely with BC&A personnel in collecting data associated with this masterplan. The following City personnel were influential in the completion of this master plan.

Dale Coulam	City Manager
Cade Visser	Director of Finance
Chuck Gillette	Public Works Director/City Engineer
Tom Jorgensen	Assistant City Engineer
Shiloh Pentz	Assistant Public Works Director of Operations

1.3.3 IVINS CITY COUNCIL

The following elected officials participated in the review and approval of this masterplan:

Chris Hart	Mayor
Sharon Barton	Councilperson
Kevin Smith	Councilperson
Sharon Gillespie	Councilperson
Lance Anderson	Councilperson
Mike Scott	Councilperson

SECTION 2 EXISTING FACILITIES

2.1 INTRODUCTION

As part of this Master Plan, BC&A has assembled an inventory of existing storm drainage infrastructure within the City. The purpose of this chapter is to present a summary of the inventory of Ivins City's existing storm drain system that can be used as a reference for future studies.

2.2 SERVICE AREA AND EXISTING FACILITIES

The City of Ivins, which was first incorporated as a town in 1935, is located about 8 miles Northwest of St. George City in Washington County, Utah. The topography of the majority of the City slopes from North to South towards the Santa Clara River. There are three main washes, Coyote Wash, Kayenta Wash, and Tuacahn Wash, which convey stormwater through the City to the Santa Clara River. Figure 2-1 shows the approximate planning extent of Ivins along with the City's storm drain collection system components. For clarity, manholes and inlet boxes are not shown on this figure.

2.2.1 STORM DRAINAGE PIPES

There are just over 209,000 feet (39 miles) of storm drain pipe, over 300 manholes/cleanouts, and nearly 1,400 inlets in the Ivins City Storm Drain System that are cataloged in the GIS database. Table 2-1 contains a summary of the storm drain pipes for the Ivins City collection system.

Table 2-1
Ivins Storm Drain Pipe Lengths

Diameter (in)	Length (ft)	Length (mi)
12	69,127	13.1
15	8,873	1.7
18	40,748	7.7
24	49,652	9.5
30	16,258	3.1
36	8,987	1.7
42	3,765	0.7
48	4,882	0.9
60	4,345	0.8
72	2,622	0.5
Total	**209,604**	**39.7**

2.2.2 FLOOD STREETS

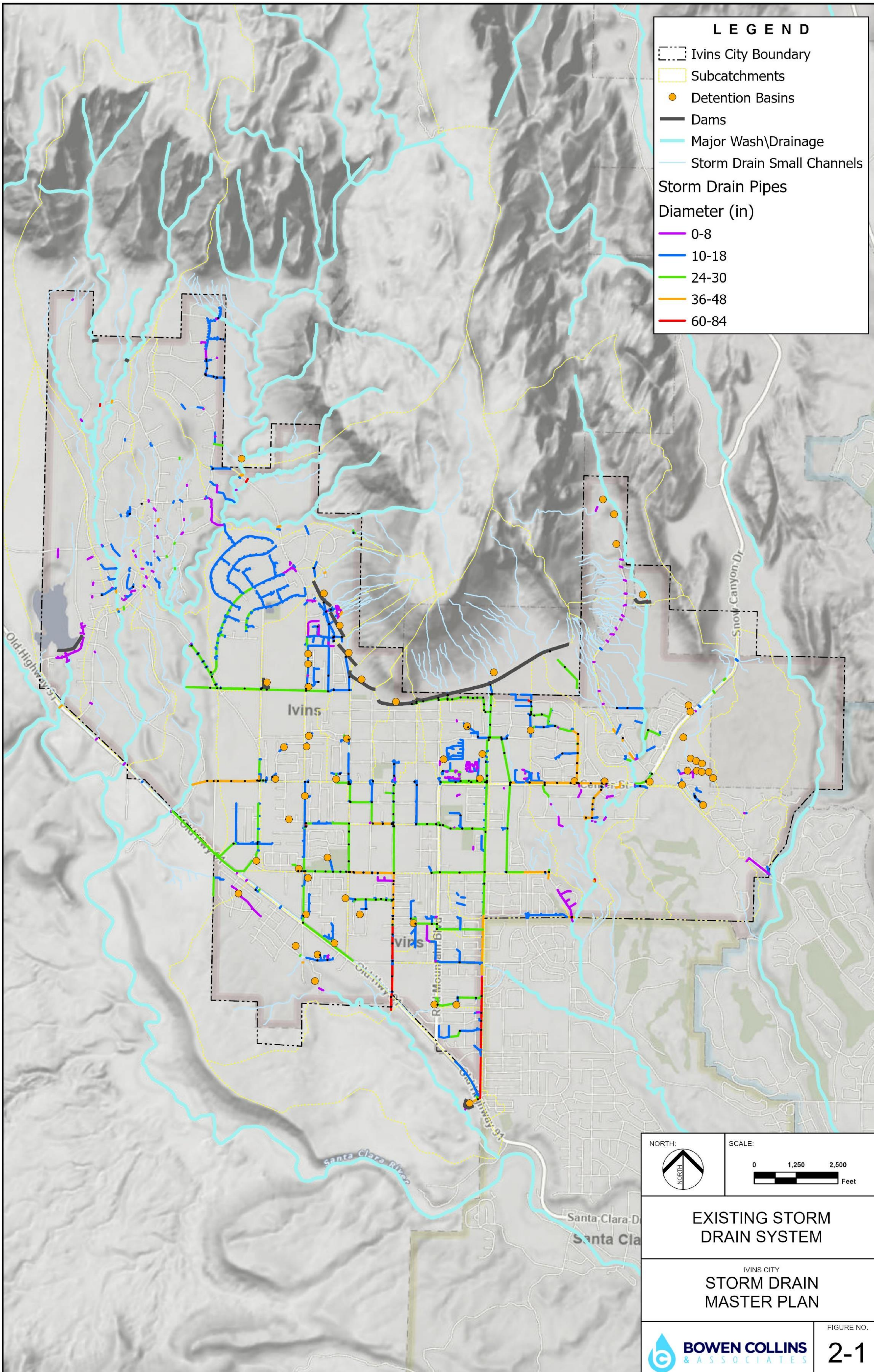
A 5,800 linear foot section of the 400 East roadway, between Center Street and 800 South, has been designated as a flood street in the storm drain system. The flood street consists of the v-shaped roadway that slopes to a waterway in the middle of the street. The waterway conveys flows to a series of inlets which collect stormwater into a network of small pipes. Flows exceeding the pipe capacity are conveyed in the roadway to the end of the street where a network of inlets allow flows to enter the trunkline system.

2.2.3 OPEN CHANNELS

There are over 54,000 feet (10 miles) of open channels which were modeled as part of the existing storm drain system. These open channels included natural and manmade/maintained channels. Open channels play a major role in conveying storm water from mountain watersheds to the Santa Clara River. They also act as an outlet for several storm drain pipes.

2.2.4 DETENTION BASINS

There are over 50 detention facilities in the existing storm drain system. The primary purpose of the detention facilities is to attenuate peak storm water discharges. Many of the detention facilities serve the dual purpose of a recreational park. The majority of these detention facilities are local detention basins and were not specifically modeled as part of this study. Figure 2-1 shows all of the detention facilities in the City's system. Figure 4-1 shows the detention basins modeled in the InfoSWMM model.



EXISTING STORM DRAIN SYSTEM

IVINS CITY

STORM DRAIN MASTER PLAN

BOWEN COLLINS & ASSOCIATES

FIGURE NO.

2-1

S:\Ivins\235-22-02 Storm Drain Master Plan, IFFP, IFA, and Rate Study\4.0 GIS\4.4 APRX\Figure Projects1.aprx cmoultrie 2/12/2024

SECTION 3 HYDROLOGIC ANALYSIS

A hydrologic computer model was developed as part of the previous Master Plan in InfoSWMM, Suite 15.0, for the purpose of estimating storm water runoff volume and peak discharges generated by a design cloudburst event. The model was calibrated as part of the previous Master Plan by comparing the results of the model with the measured depths and flows of real rainfall events. It was found that the model correlated very well with the measured rainfall data. For this 2024 Master Plan update, these same hydrologic study area assumptions were maintained.

As part of this 2024 Master Plan update, facilities and parameters in the model were updated to reflect new storm drainage infrastructure and residential/commercial development that has been constructed in recent years. InfoSWMM uses an Environmental Protection Agency Storm Water Management Model (EPA-SWMM) engine to perform computations. As with EPA-SWMM, InfoSWMM has the capability to model the hydrologic and hydraulic components of storm water runoff and was used to model both in this study. This section summarizes the hydrologic parameters and methods used in the InfoSWMM model. See Section 4 for a description of the hydraulic modeling.

The model development process includes delineating drainage basins, estimating hydrologic parameters, developing a design storm and calibrating the model. Each one of these steps is described below. Results of the hydrologic analysis are provided in Appendix A.

3.1 SUBCATCHMENT DELINEATION

Subcatchments were delineated based on existing contours and feedback from Ivins City as part of the previous master plan. For this master plan update, a simplified 2-D Hydrologic Engineering Center River Analysis System (HEC-RAS) model was developed to model the flow of surface water during a rainfall event. The 2-D model highlighted how flow accumulates and flows through City, which helped to confirm the extents and interconnections of the delineated subcatchments. Approximately 63 subcatchments were included in the model and boundaries associated with the hydrologic model are shown in Figure A-1.

3.2 HYDROLOGIC MODEL PARAMETERS

The following hydrologic model parameters were used in the InfoSWMM computer model.

3.2.1 HYDROLOGY METHOD

In the InfoSWMM software there are multiple options for Hydrology Method. The EPA-SWMM non-linear reservoir method was used in this study and is the same method EPA SWMM uses. This method requires “subcatchment width” and slope as input parameters.

3.2.1.1 Subcatchment Width

The subcatchment width is the theoretical width of the overland flow and is conceptualized as the characteristic width of a subcatchment area divided by the average maximum overland flow length. For the purpose of this report the subcatchment width was estimated using the following empirical formula built-in to InfoSWMM to get reasonable unit discharges.

$$W = k * \text{Area}^{0.5}$$

Where:

W – Subcatchment Width

k – Coefficient (typically range between 0.1 - 0.5)

Area – Subcatchment Area (acres)

Generally speaking, smaller *k* values are associated with long narrow subcatchments and larger *k* values are associated with wider subcatchments, measured approximately perpendicular to the direction of flow. Calculating exact values of *k* is difficult. Instead, the *k* value is often selected to adjust the model runoff values to better match observed or measured runoff hydrographs.

Several values of *k* were used throughout the City. These values of k varied from 0.1 to 0.4, depending on the size and slope of the subcatchment, and were selected and adjusted as part of the calibration process of the previous master plan. Those same values apply in the updated InfoSWMM model as the size and shape of the subcatchments have not changed.

3.2.1.2 Slope

The average slope for each subcatchment was calculated using a Digital Elevation Model (DEM). Ivins City provided a 3-foot resolution DEM which extended to city limits. A 10-foot resolution DEM was used for areas outside of city limits. The Arc View GIS system was used to mosaic the two DEMs together. The average slope for each subcatchment was calculated using tools within InfoSWMM. Average slopes ranged throughout the city from 2.9% to 76%.

3.2.2 LOSS METHOD

The SCS Curve Number method was used in InfoSWMM to calculate infiltration losses (see Natural Resources Conservation Service (NRCS) TR-55 publication for additional information). This method requires the input of a composite Curve Number and the percent impervious for each subcatchment.

3.2.3 COMPOSITE CURVE NUMBER

Curve Numbers were estimated for each subcatchment based on soil type and vegetative ground cover. The hydrologic soil type was obtained from the NRCS Soil Survey Geographic (SSURGO) dataset. In order to be more consistent, the NRCS recently updated the raw data for Tobler Fine Sandy Loam (T_c) from being a hydrologic soil type B to a type A. Based on past experience in the area the soil class was left as B soil type to better simulate historic runoff. Future masterplans developed in Ivins City will need to continue to classify the T_c soil type as Class B soil to match this masterplan and historic runoff. Table 3-1 shows the Curve Numbers used in this study, based on soil type and assumed vegetative ground cover for developed areas. See Figure A-2 for the location of the various soil types. Ivins has experienced multiple extreme storms where the storm distribution contained multiple peaks in a short period. For this reason, multiple Antecedent Moisture Content (AMC) conditions were considered. See Figure A-3 for boundaries where different AMC values were used.

Table 3-1
SCS Curve Number

Soil Type	Curve Number (AMC II)*	Curve Number (AMC III)**
A	63	80
B	77	89
C	85	94
D	88	95

*From Table 2-2 in TR-55 "Desert Shrub (Poor Hydrologic Condition)"[*]

[*] United States Department of Agriculture. (1988). *Urban Hydrology for Small Watersheds: TR-55.* Washington, D.C.: USDA.

** AMC III curve number were used in the mountain area†

3.2.4 DIRECTLY-CONNECTED IMPERVIOUS AREA

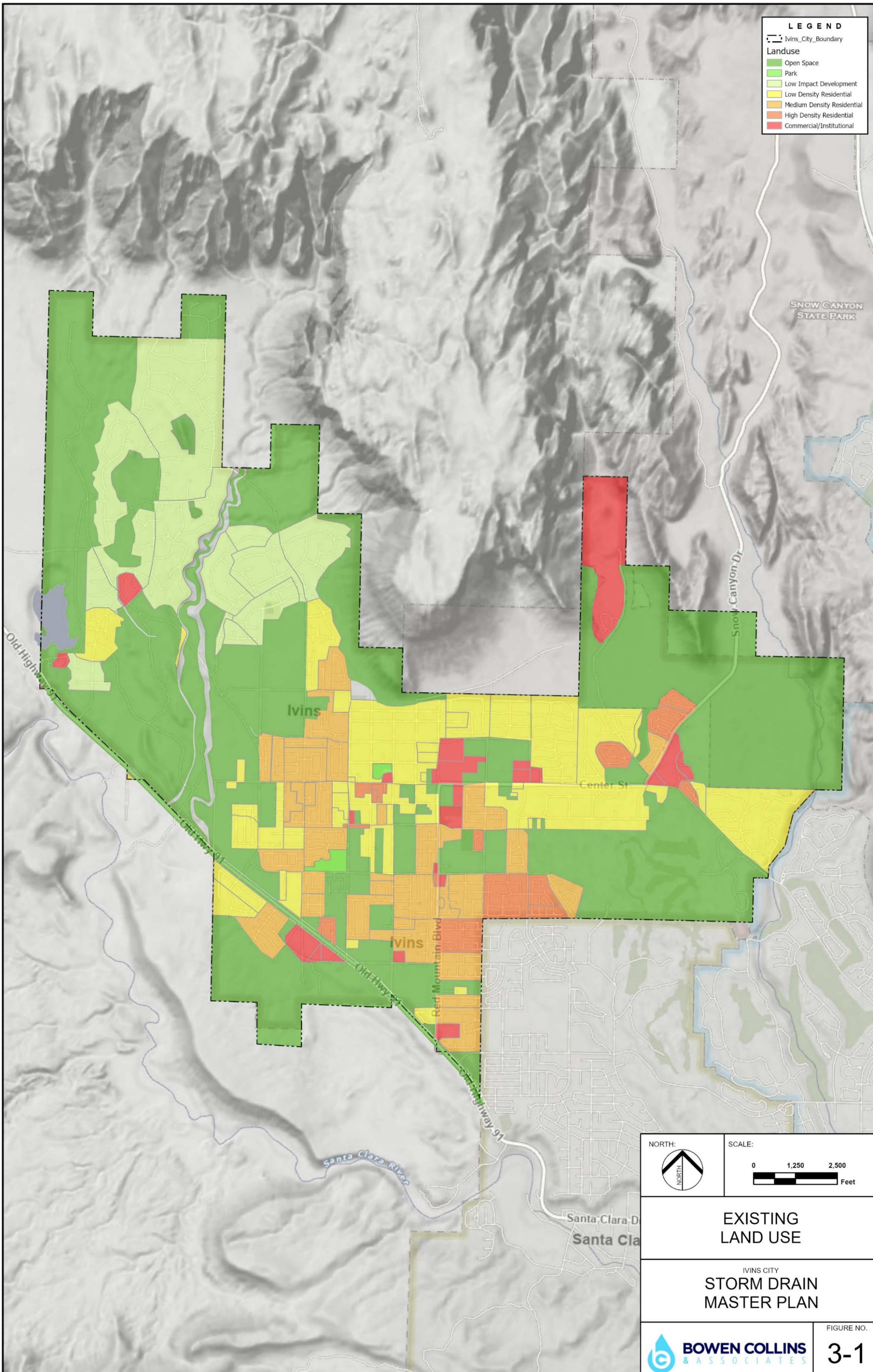
The amount of directly-connected impervious area for existing conditions was estimated using 2022 aerial imagery provided by Washington County. Impervious area parameters for subcatchments that saw significant development over the past several years were updated to reflect existing conditions. The amount of directly-connected impervious area was also estimated for full build-out conditions based on land use from the General Plan. Each Land Use type was analyzed and the estimated impervious area was recorded. For areas that are currently undeveloped, the General Plan was used in conjunction with Table 3-2 to estimate the impervious area. See Figures 3-1 and 3-2 for existing and buildout land use projections.

Table 3-2
Average Imperviousness Based on Land Use

General Plan Land Use Type	Directly Connected Imperviousness (Percent)
Open Space	0
Low Impact Development*	7-15
Low Density Residential (LDR)	18-25
Tuacahn Resort	20
Park	25
Medium Density Residential (MDR)	30-35
School	40
High Density Residential (HDR)	40-55
RMU - Village	55
Commercial/Light Manufacturing	70
Church	75
RMU-Town Center	85
Commercial	85
Commercial Neighborhood	85
Commercial Resort	85

* Note areas of Low Impact Development (LID) with a directly connected impervious area of 7 percent incorporated the use of cisterns, reducing the direct runoff to the system.

† United States Department of Agriculture. (2004). Part 630 Hydrology National Engineering Handbook. *Chapter 10: Estimation of Direct Runoff from Storm Rainfall.* Washington, D.C.: USDA.



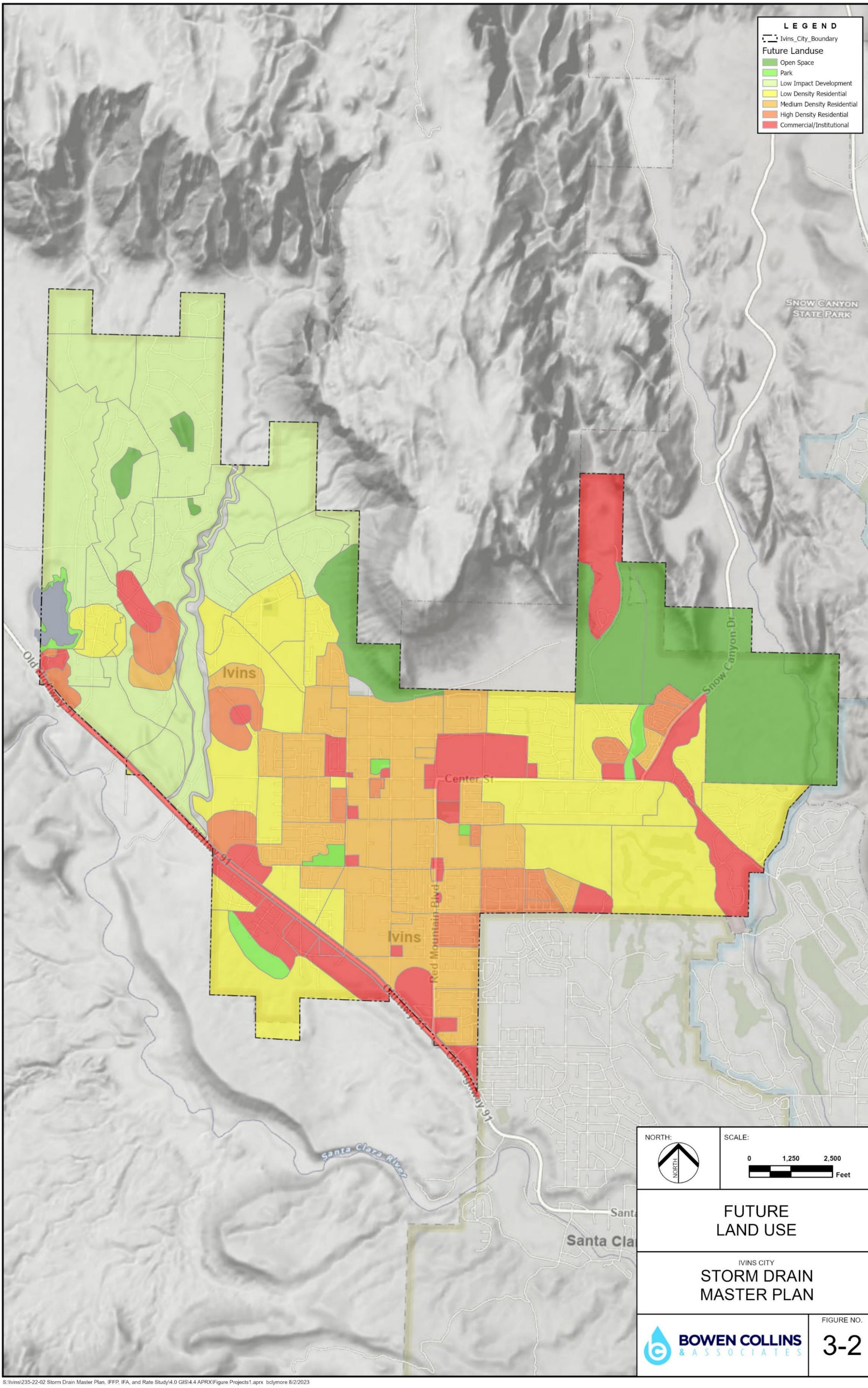
EXISTING LAND USE

IVINS CITY
STORM DRAIN MASTER PLAN

BOWEN COLLINS & ASSOCIATES

FIGURE NO. 3-1

S:\Ivins\235-22-02 Storm Drain Master Plan, IFFP, IFA, and Rate Study\4.0 GIS\4.4 APRX\Figure Projects1.aprx cmoultrie 2/12/2024



S:\Ivins\235-22-02 Storm Drain Master Plan, IFFP, IFA, and Rate Study\4.0 GIS\4.4 APRX\Figure Projects1.aprx bclymore 8/2/2023

3.3 DESIGN STORM PARAMETERS

As part of the previous Master Plan, multiple design storm boundaries were used to best represent conditions experienced by the during storm events: a Mountain Watershed Study Area, a Central Study Area, and a Valley Study Area. The InfoSWMM model was developed using these three hydrologic conditions. The model was calibrated as part of the previous Master Plan by comparing the results of the model with the measured depths and flows of real rainfall events. It was found that the model correlated very well with the measured rainfall data. For this 2024 Master Plan update, these same hydrologic study area assumptions were maintained.

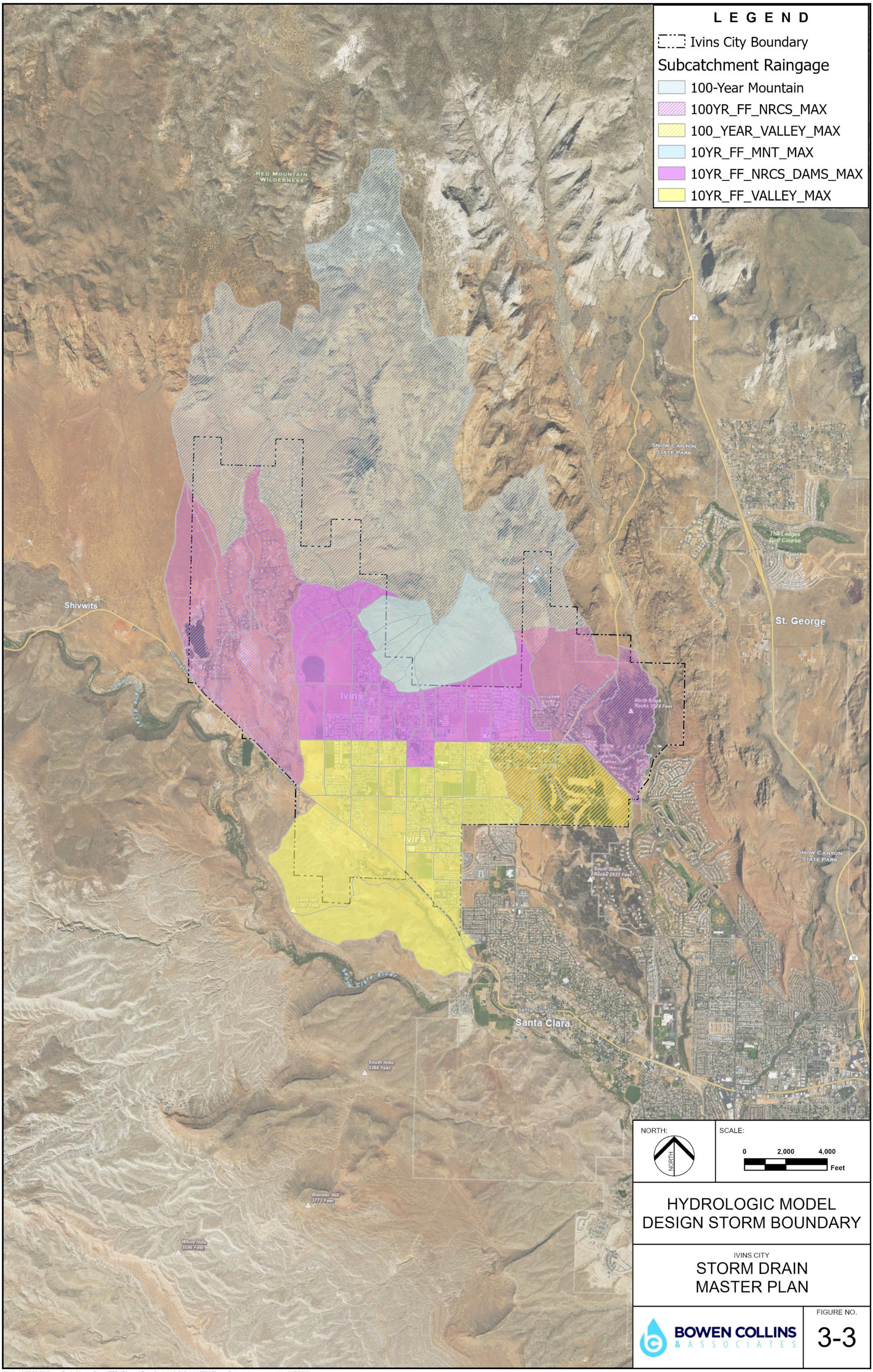
These design storm boundaries are shown on Figure 3-3. The parameters for the design storms are described below:

- Storm Duration: 3 Hours
- Storm Distribution: Modified Farmer and Fletcher
- Recurrence Interval:
  - City Drainage: 10-Year Storm
  - Mountain Drainage: 100-Year Storm
- Storm Depth (Upper Bound from NOAA Atlas 14)‡:

Mountain Area	100-Year	2.41 inches
Central Area	100-Year	2.19 inches
Central Area	10-Year	1.30 inches
Valley Area	10-Year	1.25 inches

General engineering practice is to use NOAA Atlas 14 average depths based on the design storm. Ivins City has experienced multiple extreme storms in recent years that have exceeded these average depths. The rainfall depths listed above represent Upper Bound depths. These depths were used in the model to yield results that more closely matched rainfall and runoff that was observed by City personnel in recent years. See Tables A-2 through A-4 for NOAA Atlas 14 depths.

‡ NOAA's National Weather Service. (2015). *Hydrometeorological Design Studies Center Precipitation Frequency Data Server (PFDS)*.



HYDROLOGIC MODEL
DESIGN STORM BOUNDARY

IVINS CITY
STORM DRAIN
MASTER PLAN

BOWEN COLLINS & ASSOCIATES

FIGURE NO.
3-3

S:\Ivins\235-22-02 Storm Drain Master Plan, IFFP, IFA, and Rate Study\4.0 GIS\4.4 APRX\Figure Projects1.aprx cmoultrie 11/5/2023

3.4 HYDROLOGIC MODELING ASSUMPTIONS

The following assumptions were also 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 the watershed.
3. The hydrologic computer model adequately simulates watershed response to precipitation.
4. Hydrologic parameters for non-developable areas were assumed to have normal mid-summer vegetation cover, free from recent fire damage.
5. Runoff produced by the storm event can collect in each detention basin and eventually flow into the City Facilities.
6. No areal reduction factors were included.

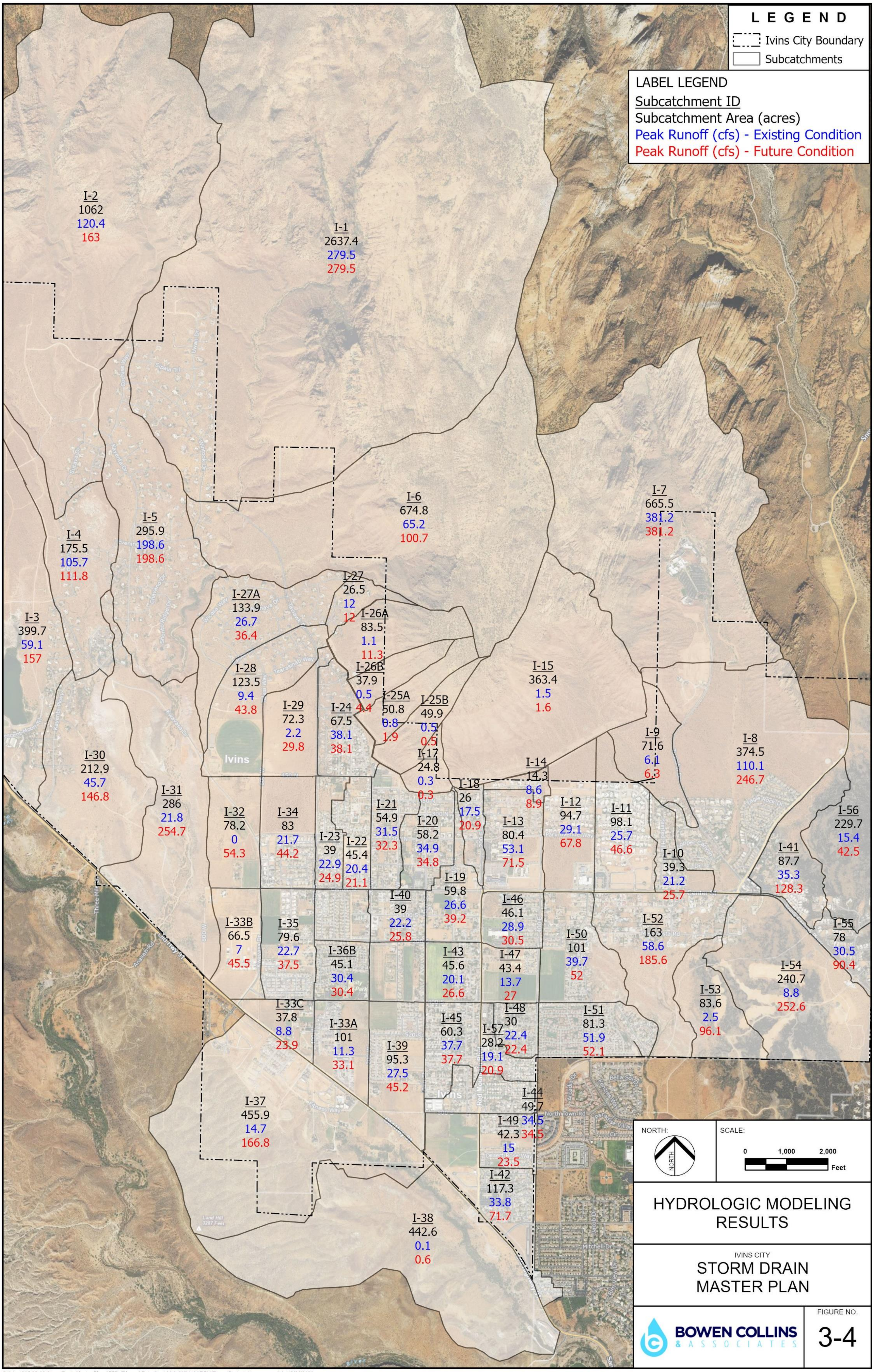
3.4.1 EXISTING INLET CAPACITY ISSUES

The collective assumption was made that there are enough existing storm water inlets in each subcatchment to collect runoff from a 10-year design storm event. In areas where ponding or flooding occurs, the inlet capacity should be evaluated and additional inlets should be added if necessary.

3.5 HYDROLOGIC MODELING SUMMARY

The parameters and assumptions described above were used in the hydrologic model to determine the peak runoff generated at each subcatchment under existing and buildout scenarios. Figure 3-4 shows subcatchment boundaries, with corresponding peak runoff values for the two scenarios. These runoff values account for the increase of impervious area in the buildout condition, but do not include future detention facilities that would attenuate the peak runoff at a given subcatchment. Table A-1 shows the runoff produced for each subcatchment.

New detention facilities and pipeline improvements are considered in Section 4, Hydraulic Modeling.



HYDROLOGIC MODELING RESULTS

IVINS CITY

STORM DRAIN MASTER PLAN

BOWEN COLLINS & ASSOCIATES

FIGURE NO.

3-4

S:\Ivins\235-22-02 Storm Drain Master Plan, IFFP, IFA, and Rate Study\4.0 GIS\4.4 APRX\Figure Projects1.aprx cmoultrie 10/21/2023

SECTION 4 HYDRAULIC MODELING

A hydraulic computer model of the study area was developed in InfoSWMM for the purpose of routing storm water runoff and estimating the capacity of the existing storm drain facilities. InfoSWMM uses an EPA-SWMM engine to perform hydraulic computations. As with EPA-SWMM, InfoSWMM can be used to model the hydrologic and hydraulic components of the study. See Chapter 3 for a description of the hydrologic modeling.

4.1 GEOMETRIC MODEL DEVELOPMENT

There are two major types of data required for a hydraulic model of a storm drain system: geometric data and flow data. Geometric data consists of all information in the model needed to represent the physical characteristics of the system, including pipelines, open channels and detention basins. Flow data is part of the hydrologic analysis reported in Chapter 3. A summary of the elements included in the previously developed hydraulic model, and updates made to the model as part of this study, are provided in the following sections.

4.1.1 MODELED CONVEYANCE

Only major storm drain trunklines were included in the hydraulic model. If more smaller pipes are added to the model, the more refined the analysis becomes, but this requires additional time, effort, and expense. Hence, it is important to consider the required accuracy and available budget when selecting the storm drain pipes to model. This analysis has correspondingly been limited to the major trunk lines (18" or larger) in the City servicing multiple developments. Project level improvements serving single developments have not been included at this time.

The InfoSWMM model was updated with information found in GIS files provided by Ivins City personnel. These files contained information regarding type, lengths, diameter, materials, and inverts for pipes. Rim elevation and invert elevation were also contained in a GIS file for manholes. This data was imported into the InfoSWMM model. Newer developments and storm drainage infrastructure information that was not reflected in the GIS data were added to the model based on as-built drawings.

It should be noted that all pipes were assumed to have a manning's roughness of 0.013 which is consistent with industry standard for concrete pipe. Open Channels were assumed to have manning's roughness of 0.035. Minor losses associated with each manhole were assumed to be 0.3.

4.1.1.1 Condition of Existing Pipe

Generally, any new storm drain pipes installed in Ivins City are reinforced concrete pipe (RCP) or corrugated high density polyethylene (HDPE). Some older sections of storm drain pipe are in poor condition due to deterioration or crushing of these pipes over time. The City hired a videographer to verify the condition of existing pipes in 400 East Street, 800 South Street, 600 South Street, 400 South Street, and 200 South Street to determine if the pipes were in need of repair or replacement.

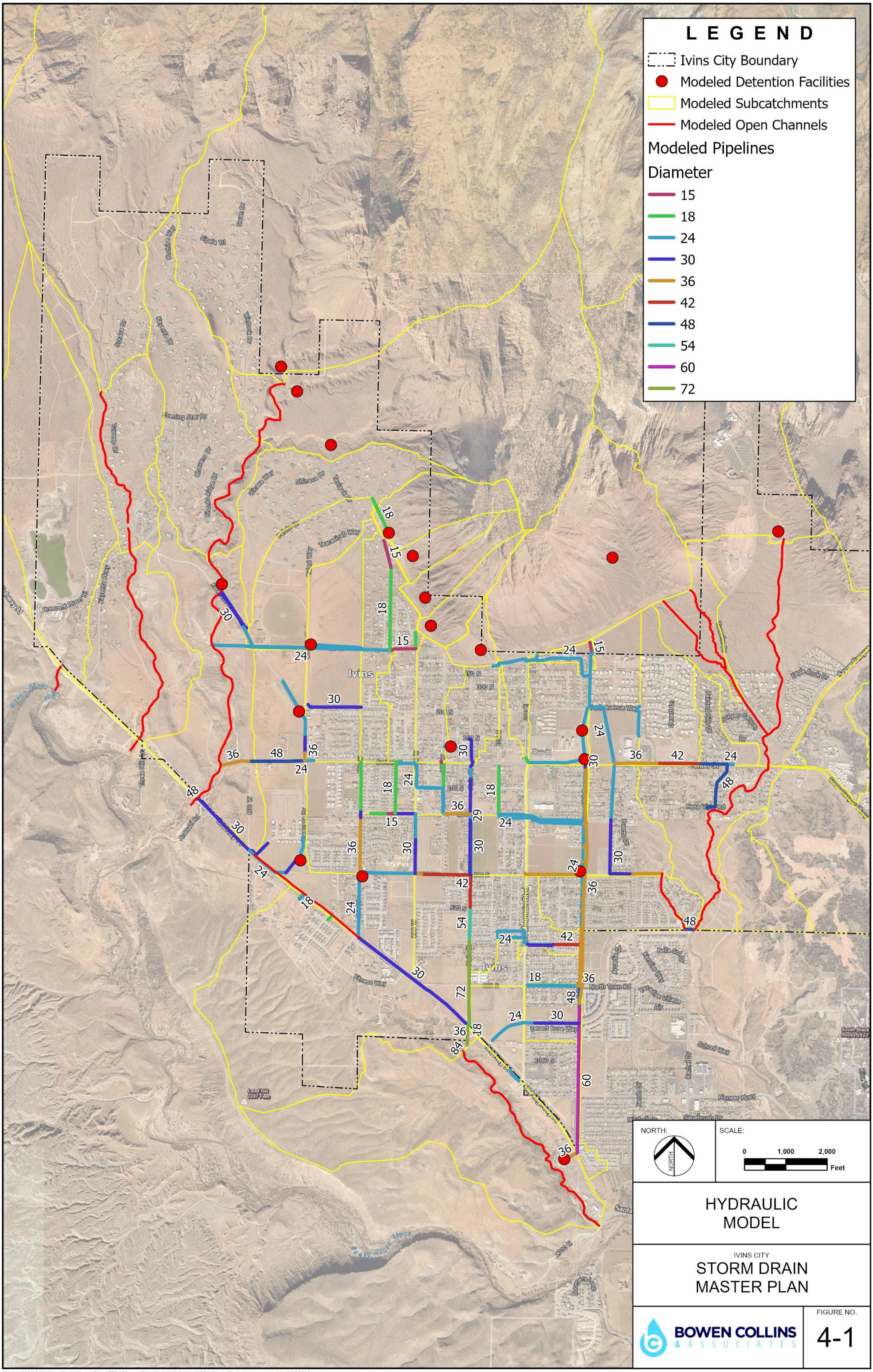
As part of the previous master plan, some projects were identified that would add a parallel storm drain pipe to increase flow capacity within a given drainage corridor. Based on the results of the videoing of the pipes, some of the existing pipes that were assumed to be in good condition were found to be in poor condition and in need of replacement. In those cases, projects that previously recommended a parallel pipe were updated to recommend the replacement of the existing pipe with a larger pipe to both remove the damaged existing pipe and to increase the flow capacity within the drainage corridor. These changes to the proposed pipeline project were reflected in the updated hydraulic model.

4.1.2 DETENTION BASINS

Stage-storage curves were provided by City personnel for existing detention basins and were entered into the model. Orifice information, including size, location, or lack thereof, was provided by the City, and was included in the existing conditions model. Future detention basins were modeled with a synthetic stage storage curve and an orifice to control the release rate. Figure 4-1 shows the facilities modeled in the InfoSWMM model, including existing and proposed detention basins and pipelines.

Detention facilities are either local or regional. The City's current policy is for future developments to detain runoff such that the flow exiting a given development during the 100-yr design storm event is 0.2 cfs/acre. This assumed detained flow rate was included in the future conditions model.

In some cases, the City will negotiate with the developer to build a regional detention facility in lieu of the developer providing local detention. The City identified some locations where regional detention facilities would likely be installed, and these detention basins were also included in the future condition model.



S:\Ivins\235-22-02 Storm Drain Master Plan, IFFP, IFA, and Rate Study\4.0 GIS\4.4 APRX\Figure Projects1.aprx cmoultrie 11/5/2023

SECTION 5 SYSTEM EVALUATION

Using the updated hydraulic storm drain model, it is possible to simulate storm drain system operating conditions for both existing and future conditions. The purpose of this chapter is to document the hydraulic performance evaluation of the collection system and identify potential hydraulic deficiencies.

5.1 IMPERVIOUS AREA GROWTH PROJECTIONS

When planning for future storm drain infrastructure, the final buildout scenario was considered. The buildout scenario identifies the storm drainage infrastructure that will be required when the impervious area in the City is built out to the maximum extents based on development types defined in its future land use plan. Not all recommended projects can be built at once, so the timing of when each proposed project is completed is dependent on where and when growth of impervious areas occurs in the City. Population growth projections are helpful in determining the timing of construction of storm drain improvements.

5.1.1 POPULATION GROWTH

Ivins City personnel provided historic population growth data and population growth projections for reference in this analysis. The Ivins City population in 2024 was listed at 10,484 people. The estimated population at buildout is approximately 19,500 people. The timing of when that buildout scenario is realized depends on the growth rate assumed. Ivins City has historically grown on average 40% every 10 years. To project future growth in the City, City personnel have developed three projected growth curves based on a geometric growth rate, a linear growth rate, and a decelerating growth rate. Based on feedback from City personnel, the linear growth rate, where the population increases by the same number of people each year, was the preferred growth rate condition for the purpose of projecting growth in the City.

Using population projections only to predict how much impervious area will be developed is appropriate when the future development is expected to consist of the same density of impervious area as historic development. For Ivins City, most of its historic growth has been residential developments, with relatively few commercial/industrial developments. In projecting future growth in the City, it is anticipated that a higher portion of total development will be commercial/industrial when compared to historic growth. Commercial and industrial developments generally have a higher amount of impervious area compared to residential development. To account for the additional growth in impervious area due to the increased amount of future commercial and industrial development, equivalent residential unit (ERU) growth was considered.

5.1.2 ERU GROWTH

The linear population growth projection was used to determine the projected growth of residential ERUs in the City. City personnel provided the projected commercial/industrial ERU growth based on the latest water and sewer master plan updates. Total projected future ERUs were determined by adding the projected residential ERUs together with the projected commercial/industrial ERUs. These projections were used in determining the priority of proposed storm drain projects, as well as for projecting costs and revenues as part of the Impact Fee Analysis and Storm Drainage Fee Rate Study.

5.2 EVALUATION CRITERIA AND LEVEL OF SERVICE

To evaluate deficiencies in the system, the desired level of service for each of the storm drain components needs to be defined.

5.2.1 STORM DRAIN PIPELINES

Storm drain pipelines do not surcharge into the street during the 10-year storm event. It is important to note that roadways become the major storm water conveyance facility during storms that are larger than the 10-year design event.

5.2.2 FLOOD STREETS

Flood Streets are designed to convey the 10-year storm in the low flow pipe network underneath the roadway. In the 100-year event the flood streets are designed to fill such that a minimum of 1 lane or 10.5 feet in either direction is not submerged.

5.2.3 OPEN CHANNELS

Open channels should be designed to safely convey the 100-year design storm event.

5.2.4 CULVERTS

Culverts should be designed to safely convey the 100-year design storm event.

5.2.5 DETENTION BASINS

Detention facilities should be designed to have capacity for the 100-year design storm. Since pipes are designed for the 10-year design storm it is recommended that all detention facilities have a structure that allows flows from the streets to enter the detention facility. It is also recommended that all detention facilities have an emergency overflow that directs water away from private property in an event larger than the 100-year design storm.

5.3 EXISTING CONVEYANCE SYSTEM ANALYSIS

Figure 5-1 shows the deficiencies in the storm drain system under existing development conditions. As can be seen from the Figure, culverts, detention basins, and trunklines were found to be deficient.

Pipeline deficiencies were identified wherever the capacities of the existing pipe were insufficient to convey the design storm event flow rate. In the model, these situations are represented by flow exiting a pipeline by bubbling up through manhole lids or catch basin inlets.

5.3.1 400 EAST/FLOOD STREET ANALYSIS

The InfoSWMM model evaluated the existing capacity of the storm drain pipelines within 400 East. However, 400 East is a uniquely important drainage corridor as it is the only road designed as a flood street that is expected to convey significant flows during large storm events. For that reason, 400 East was evaluated in more detail using a spreadsheet model.

400 East is an inverted road where runoff primarily accumulates in the center of the road instead of along the curb and gutter. A concrete gutter is located in the center of the road to help convey the accumulated runoff. Grated inlet structures are located within this gutter at various locations to capture runoff during smaller storm events.

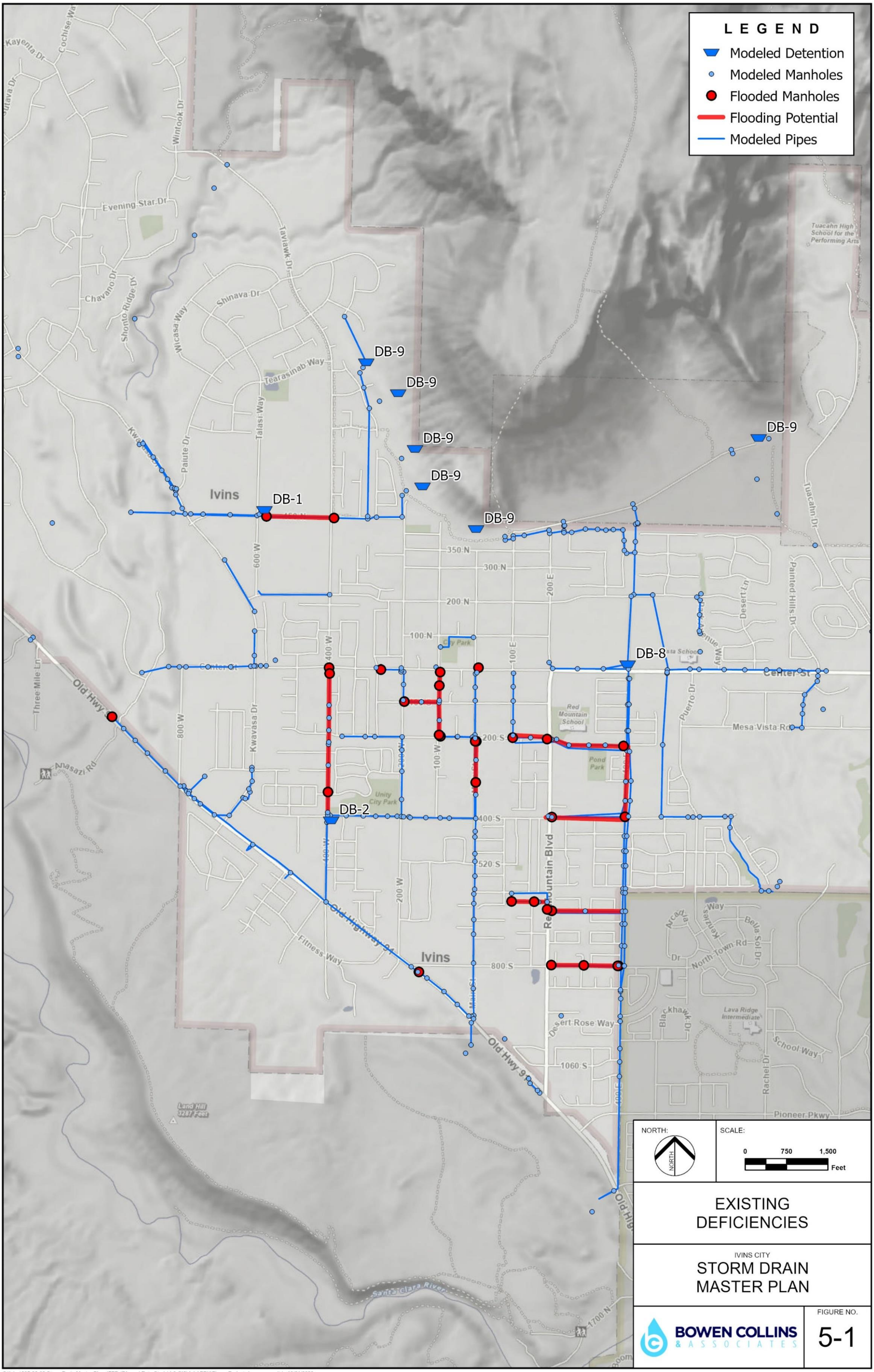
The spreadsheet model used LiDAR data to calculate the roads capacity to convey runoff while maintaining water levels low enough to allow a 10.5-foot traffic lane on both sides of the flow. 400 East Street is not completely built yet, and under current conditions runoff conveyed down 400 East would spill out onto adjacent undeveloped property. As these properties are developed, the road will eventually be completed, and this future scenario was also modeled. It was found that the existing pipelines are sufficient to convey the 10-year design storm event. However, during the 100-year design flood event, runoff flows do exceed the capacity of the 400 East Street in places. For this reason, it is recommended to upsize the storm drain pipeline in 400 East as the area continues to develop. By upsizing this pipeline, more water can be captured and conveyed through the pipeline, freeing up additional space in the 400 East inverted street to better convey runoff during large storm events while maintaining adequate traffic lane widths so transportation is impeded as little as possible.

5.4 FUTURE CONVEYANCE SYSTEM ANALYSIS

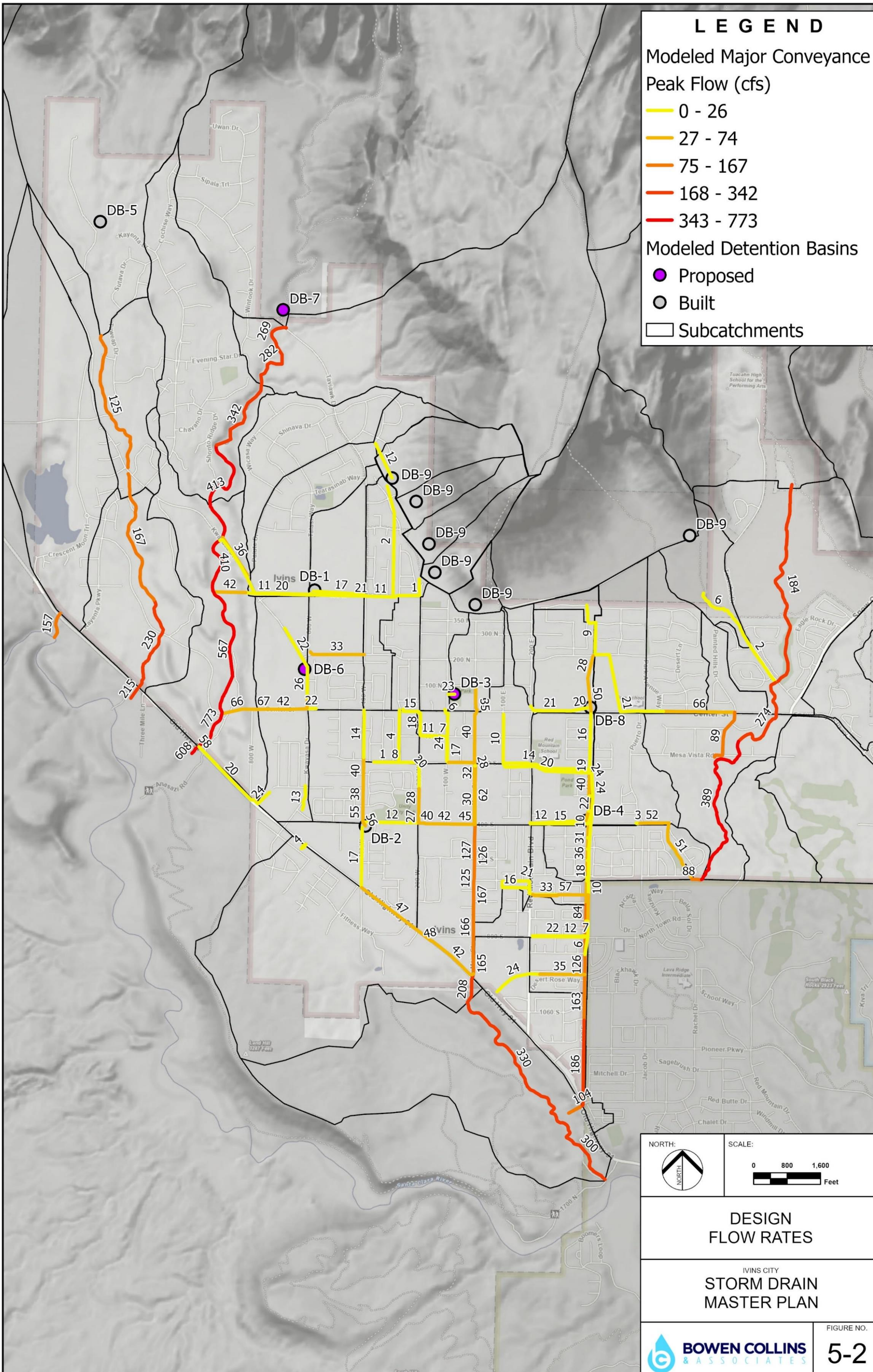
A few of the existing storm drain collection trunklines in Ivins are undersized for ultimate development conditions. Additional trunklines will need to be constructed for future development. Also, there are several detention basins that need to be constructed or modified to help alleviate flood and conveyance pressure on the existing storm drain system.

Design flow rates for sizing storm drain pipes were determined by referencing both the existing condition and future buildout model results. Figure 5-2 shows these design flow rates for the trunklines modeled as part of this master plan.

Chapter 6 discusses conceptual improvements that will be needed to fix existing deficiencies and allow for planned future growth.



S:\Ivins\235-22-02 Storm Drain Master Plan, IFFP, IFA, and Rate Study\4.0 GIS\4.4 APRX\Figure Projects1.aprx cmoultrie 10/21/2023



S:\Ivins\235-22-02 Storm Drain Master Plan, IFFP, IFA, and Rate Study\4.0 GIS\4.4 APRX\Figure Projects1.aprx cmoultrie 10/24/2023

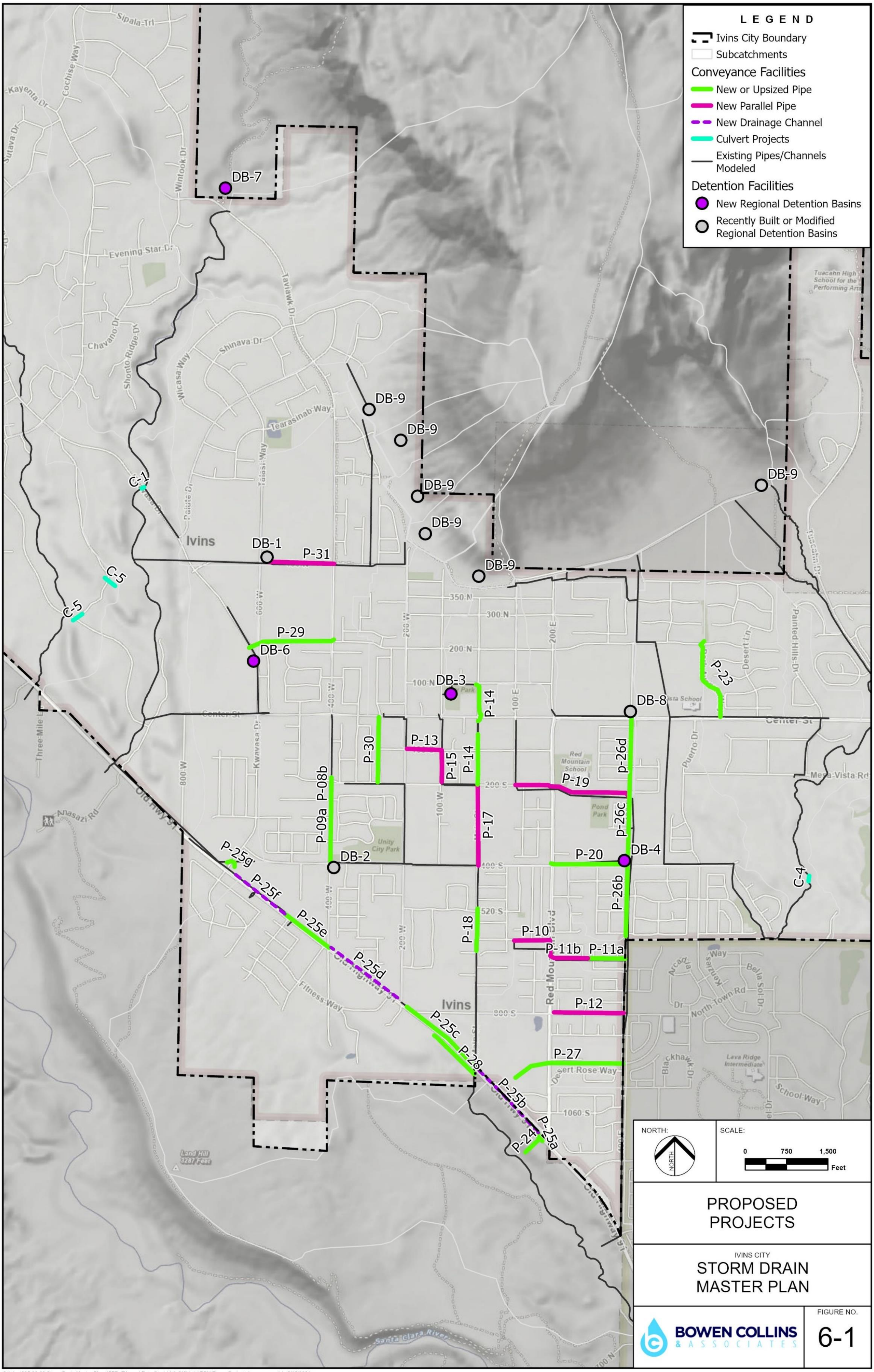
SECTION 6 RECOMMENDED SYSTEM IMPROVEMENTS

The results of the InfoSWMM model were used to evaluate various alternatives for mitigating the identified existing deficiencies and sizing future storm drain facilities under projected future development conditions. This chapter describes the storm drain improvements, based on estimated runoff and ground slopes.

6.1 RECOMMENDED PIPELINE IMPROVEMENTS

Figure 6-1 shows the location of recommended pipeline improvements that are needed to meet future growth in Ivins City. A total cost for each project has been provided. Unit costs associated with the total project costs were developed based on past projects, master planning experience, and coordination with City personnel. A table showing these unit costs can be seen in Appendix B.

As can be seen in Figure 6-1 a combination of parallel and replacement pipeline projects are proposed. Whether a parallel pipe or replacement was recommended was based on conversations with City personnel, as well as the size, material, condition, and age of the existing pipes. Table 6-1 summarizes the cost of the proposed pipe improvements in 2023 dollars. Costs for all projects have been divided into two priority groups. Priority 1 projects are planned to be constructed in the next 10-years, whereas priority 2 projects are lower priority projects and are planned for some time after 2033. Conversations with City personnel were critical in identifying which projects had a higher priority.



S:\Ivins\235-22-02 Storm Drain Master Plan, IFFP, IFA, and Rate Study\4.0 GIS\4.4 APRX\Figure Projects1.aprx cmoultrie 2/12/2024

Table 6-1
Storm Drain Trunkline Improvements

Project ID	Project Location	Priority 1 (immediate) Estimated Cost	Priority 2 (future) Estimated Cost	Existing Pipe Size (in)	Future Pipe Size (in)	Existing Parallel Pipe Flow (cfs)	Future Flow/Release Rate (cfs)	Total Future Flow (cfs)	Description
P-08b	400 W & 200 S	$64,808	-	18	30	-	40	40	Replace existing 18" with 30" pipe
P-09a	400 W & 400 S	$452,238	-	18-24	36	-	55	55	Replace existing 18"-24" with 36" pipe
P-10	160 E & 625 S	-	$280,488	24	24	16	21	37	Future parallel 24" pipe
P-11a	285 E & 650 S	-	$262,704	24	42	-	55	55	Replace 24" pipe in poor condition with 42" pipe
P-11b	285 E & 650 S		$168,355	24	30	24	32	56	Future parallel 30" pipe
P-12	320 E & 800 S	-	$331,798	18	24	12	22	34	Future parallel 24" pipe
P-13	150 W & 100 S	-	$174,487	24	24	7	11	18	Future parallel 24" pipe
P-14	100 N & Main Str.	-	$498,193	18-24	30	-	40	40	Replace existing 18"-24" with 30" pipe
P-15	100 W & 150 S	-	$160,941	24	24	16	23	39	Future parallel 24" pipe
P-17	350 S & Main Str.	-	$449,502	24	30	30	60	90	Future parallel 36" pipe
P-18	490 S & Main Str.	-	$372,882	42	54	-	124	124	Replace 42” with 54” pipe
P-19	250 E & 200 S	$593,046	-	24	24	14	20	34	Future parallel 24" pipe
P-20	250 E & 400 S	$472,655	-	24	36	-	26	26	Replace deteriorated 24" pipe with new 36" pipe
P-23	Park Avenue Way	$436,881	-	-	24	-	11	11	New 24" pipe to help control debris flows
P-24	Hwy 91 & Red Mtn. Blvd.	$70,000	-	-	24	-	8	8	New 24" pipe to discharge to wash
P-25a	Hwy 91 (400 W to 550 W)	$70,700	-	-	24	-	8	8	New 24" pipe
P-25c	Hwy 91 (200 W to Main St.)	$318,150	-	-	36	-	43	43	New 30" to 36" pipes (built with Hwy 91 road project)

Project ID	Project Location	Priority 1 (immediate) Estimated Cost	Priority 2 (future) Estimated Cost	Existing Pipe Size (in)	Future Pipe Size (in)	Existing Parallel Pipe Flow (cfs)	Future Flow/Release Rate (cfs)	Total Future Flow (cfs)	Description
P-25e	Hwy 91 (500 W to 400 W.)	$247,450	-	-	36	-	18	18	New 30" to 36" pipes (built with Hwy 91 road project)
P-25g	Hwy 91 (Kwavasa Dr.)	$70,700	-	-	18	-	6	6	New 18" pipe for collection near Kwavasa Dr.
P-26b*	400 East (400 S to 580 S)	$609,403	-	24	42	-	51	51	Replace existing 24" pipe with new 42" pipe and concrete waterway
P-26c*	400 East (200 S to 400 S)	-	$367,722	24	42	-	61	61	Replace existing 24" pipe with new 42" pipe and concrete waterway
P-26d*	400 East (Center St to 200 S)	-	$518,416	24	36	-	20	20	Replace existing 24" pipe with new 36" pipe and concrete waterway
P-27	Western Corridor	-	$561,660	-	30	-	34	34	Future 30" pipe
P-28	RV Park @ Hwy 91	$70,000	-	-	18	-	12	12	Future 18" pipe
P-29	200 North	$318,698	-	-	30	-	33	33	Future 30" pipe
P-30	265 West Dirt Road	$190,115	-	-	18	-	6	6	Future 18" pipe
P-31	450 North Pipeline	-	$216,496	24	18	20	17	37	Future parallel 24" pipe
P-31a	450 North Inlets	$50,000	-	-	-	-	-	-	Catch basins to increase inlet capacity to 450 North pipeline
	Trunkline Total**	**$4,034,844**	**$4,363,644**						

* Project 26 is located in 400 East (Flood Street) which is an inverted street that acts as a major drainage corridor for both 10-yr and 100-yr floods. Modeling indicated that 400 East does not have sufficient capacity to convey the 100-yr storm event while maintaining travel lanes in both directions. The recommended P-26 pipes are oversized so that excess water in the street during the 100-yr event can instead be conveyed through the buried pipeline network.

** These totals include the proposed conveyance projects only. Ivins City intends to build a new public works yard, and 5% of the cost of that facility is attributable to storm drain operation and maintenance.

6.2 DETENTION BASIN IMPROVEMENTS

Figure 6-1 shows the location of recommended detention basin improvements that are needed to meet future growth in Ivins City. Table 6-2 lists the recommended detention volumes and costs for detention facilities in Ivins City.

Table 6-2
Required Capacity at Detention Basins

Project ID	Project Location	Priority 1 (immediate) Estimated Cost	Priority 2 (future) Estimated Cost	Future Release Rate (cfs)	Storage Volume (ac-ft)	Description
DB-3	City Park Baseball Field	-	$275,000	9	4.2	New 4.2 AF Detention Facility. Install inlets in 100 West to convey flows to detention facility
DB-4	400 E & 400 S	$445,000	-	24	3.4	New 3.4 AF Detention Facility
DB-6	600 W & 200 N	$272,000	-	6	1.8	New 1.8 Detention Facility
DB-7	Taviawk Dr.	-	$85,000	-	0	Construct Emergency Spillway at existing road crossing
	Detention Total	**$717,000**	**$360,000**			

6.3 CULVERT IMPROVEMENTS

Figures 6-1 shows the location of recommended culvert improvements that are needed to meet future growth in Ivins City. Table 6-3 lists the recommended culvert sizes and costs needed in Ivins City.

Table 6-3
Required Capacity at Culverts

Project ID	Project Location	Priority 1 (immediate) Estimated Cost	Priority 2 (future) Estimated Cost	Future Flow Rate (cfs)	Future Culvert Size (ft)	Existing Culvert Size (ft)	Project ID
C-1*	Kwavasa Dr. Culvert	-	$175,000	833	54”	8'	New parallel 54” culvert
C-4	Remove SITLA Culverts	$100,000	-	-	-	-	Remove existing culverts to restore natural wash channel capacity
C-5	Kayenta Box Culverts	$200,000	-	230	10'x4'	-	Two new box culverts to be installed when new road is built
	Culvert Total	**$300,000**	**$175,000**				

* Developer responsible for the upsize of the culvert.

For a detailed cost estimate of each of the recommended improvements, see Appendix B.

APPENDIX A – HYDROLOGIC INFORMATION

Table A1: Subcatchment Runoff

		Peak Runoff (cfs)		
ID	Subcatchment Area (ac)	Existing Model Output	Future Model Output	Limited to 0.2 cfs/acre
I-1	2637.4	279.5	279.5	527.5
I-10	39.3	21.2	25.7	7.9
I-11	98.1	25.7	46.6	19.6
I-12	94.7	29.1	67.8	18.9
I-13	80.4	53.1	71.5	16.1
I-14	14.3	8.6	8.9	2.9
I-15	363.4	1.5	1.6	72.7
I-17	24.8	0.3	0.3	5.0
I-18	26.0	17.5	20.9	5.2
I-19	59.8	26.6	39.2	12.0
I-2	1062.0	120.4	163.0	212.4
I-20	58.2	34.9	34.8	11.6
I-21	54.9	31.5	32.3	11.0
I-22	45.4	20.4	21.1	9.1
I-23	39.0	22.9	24.9	7.8
I-24	67.5	38.1	38.1	13.5
I-25A	50.8	0.8	1.9	10.2
I-25B	49.9	0.5	0.5	10.0
I-26A	83.5	1.1	11.3	16.7
I-26B	37.9	0.5	4.4	7.6
I-27	26.5	12.0	12.0	5.3
I-27A	133.9	26.7	36.4	26.8
I-28	123.5	9.4	43.8	24.7
I-29	72.3	2.2	29.8	14.5
I-3	399.7	59.1	157.0	79.9
I-30	212.9	45.7	146.8	42.6
I-31	286.0	21.8	254.7	57.2
I-32	78.2	0.0	54.3	15.6
I-33A	63.2	11.3	33.1	12.6
I-33B	66.5	7.0	45.5	13.3
I-33C	37.8	8.8	23.9	7.6
I-34	83.0	21.7	44.2	16.6
I-35	79.6	22.7	37.5	15.9
I-36A	36.2	20.5	24.6	7.2
I-36B	45.1	30.4	30.4	9.0
I-37	455.9	14.7	166.8	91.2
I-38	442.6	0.1	0.6	88.5
I-39	95.3	27.5	45.2	19.1
I-4	175.5	105.7	111.8	35.1
I-40	39.0	22.2	25.8	7.8
I-40B	44.9	11.6	27.8	9.0
I-41	87.7	35.3	128.3	17.5
I-42	117.3	33.8	71.7	23.5
I-43	45.6	20.1	26.6	9.1
I-44	49.7	34.5	34.6	9.9
I-45	60.3	37.7	37.7	12.1
I-46	46.1	28.9	30.5	9.2
I-47	43.4	13.7	27.0	8.7
I-48	30.0	22.4	22.4	6.0
I-49	42.3	15.0	23.5	8.5
I-5	295.9	198.6	198.6	59.2
I-50	101.0	39.7	52.0	20.2
I-51	81.3	51.9	52.1	16.3
I-52	163.0	58.6	185.6	32.6
I-53	83.6	2.5	96.1	16.7
I-54	240.7	8.8	252.6	48.1
I-55	78.0	30.5	90.4	15.6
I-56	229.7	15.4	42.5	45.9
I-57	28.2	19.1	20.9	5.6
I-6	674.8	65.2	100.7	135.0
I-7	665.5	381.2	381.2	133.1
I-8	374.5	110.1	246.7	74.9
I-9	71.6	6.1	6.3	14.3

Table A-2: Valley Depths

NOAA Atlas 14, Volume 1, Version 5
Location name: Ivins, Utah, US*
Latitude: 37.1640°, Longitude: -113.6699°
Elevation: 3020 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.134 (0.115-0.159)	0.173 (0.148-0.206)	0.234 (0.199-0.278)	0.288 (0.244-0.344)	0.372 (0.309-0.442)	0.443 (0.363-0.528)	0.526 (0.422-0.629)	0.620 (0.484-0.746)	0.764 (0.573-0.935)	0.890 (0.648-1.10)
10-min	0.205 (0.175-0.242)	0.263 (0.226-0.313)	0.356 (0.303-0.424)	0.438 (0.371-0.524)	0.565 (0.470-0.673)	0.674 (0.553-0.804)	0.801 (0.642-0.958)	0.943 (0.736-1.14)	1.16 (0.872-1.42)	1.35 (0.987-1.67)
15-min	0.254 (0.216-0.300)	0.326 (0.279-0.388)	0.442 (0.376-0.525)	0.543 (0.460-0.649)	0.701 (0.583-0.834)	0.836 (0.685-0.996)	0.993 (0.796-1.19)	1.17 (0.912-1.41)	1.44 (1.08-1.76)	1.68 (1.22-2.07)
30-min	0.341 (0.291-0.404)	0.439 (0.376-0.522)	0.595 (0.507-0.708)	0.732 (0.619-0.874)	0.943 (0.785-1.12)	1.13 (0.923-1.34)	1.34 (1.07-1.60)	1.57 (1.23-1.90)	1.94 (1.46-2.37)	2.26 (1.65-2.79)
60-min	0.423 (0.361-0.500)	0.543 (0.466-0.646)	0.736 (0.627-0.876)	0.906 (0.766-1.08)	1.17 (0.972-1.39)	1.39 (1.14-1.66)	1.65 (1.33-1.98)	1.95 (1.52-2.35)	2.40 (1.80-2.94)	2.80 (2.04-3.45)
2-hr	0.513 (0.447-0.595)	0.644 (0.562-0.749)	0.846 (0.736-0.981)	1.02 (0.886-1.19)	1.30 (1.10-1.50)	1.53 (1.28-1.77)	1.79 (1.47-2.08)	2.08 (1.67-2.45)	2.53 (1.96-3.02)	2.92 (2.20-3.53)
3-hr	0.570 (0.505-0.653)	0.713 (0.632-0.819)	0.920 (0.813-1.05)	1.10 (0.963-1.25)	1.36 (1.18-1.55)	1.58 (1.35-1.81)	1.83 (1.53-2.11)	2.11 (1.73-2.46)	2.54 (2.03-3.05)	2.93 (2.28-3.56)
6-hr	0.709 (0.631-0.806)	0.888 (0.795-1.01)	1.13 (1.01-1.28)	1.33 (1.18-1.52)	1.62 (1.42-1.84)	1.86 (1.60-2.12)	2.12 (1.81-2.43)	2.41 (2.02-2.79)	2.86 (2.33-3.36)	3.24 (2.58-3.85)
12-hr	0.866 (0.779-0.971)	1.09 (0.975-1.22)	1.37 (1.22-1.54)	1.60 (1.43-1.80)	1.91 (1.69-2.15)	2.15 (1.88-2.43)	2.40 (2.08-2.73)	2.67 (2.29-3.06)	3.05 (2.55-3.53)	3.40 (2.79-3.97)
24-hr	1.02 (0.947-1.10)	1.27 (1.18-1.37)	1.59 (1.48-1.71)	1.84 (1.71-1.98)	2.19 (2.02-2.35)	2.45 (2.26-2.63)	2.73 (2.50-2.93)	3.00 (2.73-3.23)	3.38 (3.04-3.65)	3.67 (3.27-4.00)
2-day	1.13 (1.05-1.21)	1.41 (1.32-1.51)	1.76 (1.64-1.88)	2.04 (1.90-2.18)	2.41 (2.24-2.58)	2.71 (2.51-2.89)	3.00 (2.77-3.22)	3.31 (3.04-3.56)	3.72 (3.38-4.01)	4.04 (3.64-4.37)
3-day	1.22 (1.14-1.30)	1.52 (1.42-1.63)	1.89 (1.77-2.02)	2.19 (2.05-2.34)	2.59 (2.42-2.77)	2.91 (2.70-3.10)	3.23 (2.98-3.45)	3.55 (3.27-3.81)	3.99 (3.63-4.30)	4.33 (3.91-4.69)
4-day	1.30 (1.22-1.40)	1.63 (1.53-1.74)	2.03 (1.90-2.17)	2.35 (2.20-2.50)	2.77 (2.60-2.95)	3.11 (2.90-3.32)	3.45 (3.20-3.69)	3.80 (3.50-4.07)	4.26 (3.89-4.59)	4.63 (4.18-5.00)
7-day	1.51 (1.41-1.63)	1.89 (1.76-2.03)	2.35 (2.19-2.52)	2.71 (2.53-2.90)	3.20 (2.97-3.42)	3.56 (3.30-3.81)	3.94 (3.63-4.21)	4.30 (3.95-4.63)	4.79 (4.36-5.17)	5.16 (4.66-5.59)
10-day	1.68 (1.56-1.81)	2.10 (1.95-2.26)	2.62 (2.44-2.81)	3.02 (2.81-3.24)	3.56 (3.30-3.81)	3.96 (3.66-4.24)	4.36 (4.02-4.68)	4.76 (4.37-5.13)	5.29 (4.81-5.71)	5.68 (5.14-6.17)
20-day	2.12 (1.96-2.28)	2.65 (2.46-2.85)	3.27 (3.04-3.51)	3.73 (3.46-4.00)	4.30 (3.99-4.61)	4.71 (4.36-5.05)	5.11 (4.71-5.48)	5.48 (5.03-5.89)	5.93 (5.43-6.40)	6.25 (5.70-6.76)
30-day	2.53 (2.34-2.73)	3.17 (2.94-3.42)	3.92 (3.64-4.22)	4.48 (4.15-4.82)	5.18 (4.80-5.58)	5.69 (5.26-6.13)	6.19 (5.70-6.67)	6.66 (6.11-7.20)	7.24 (6.61-7.85)	7.66 (6.96-8.33)
45-day	3.02 (2.78-3.28)	3.79 (3.49-4.11)	4.72 (4.34-5.11)	5.40 (4.97-5.85)	6.28 (5.77-6.78)	6.91 (6.34-7.47)	7.52 (6.88-8.14)	8.11 (7.40-8.79)	8.82 (8.02-9.59)	9.32 (8.45-10.2)
60-day	3.44 (3.16-3.75)	4.32 (3.97-4.71)	5.38 (4.94-5.84)	6.15 (5.64-6.67)	7.14 (6.53-7.74)	7.84 (7.16-8.51)	8.52 (7.76-9.26)	9.16 (8.32-9.97)	9.96 (9.00-10.9)	10.5 (9.46-11.5)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Back to Top

PF graphical

Table A-3: Central Depths

NOAA Atlas 14, Volume 1, Version 5
Location name: Dammeron Valley, Utah, US*
Latitude: 37.1795°, Longitude: -113.6790°
Elevation: 3767 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.140 (0.120-0.166)	0.180 (0.154-0.215)	0.244 (0.208-0.291)	0.300 (0.253-0.360)	0.386 (0.320-0.461)	0.460 (0.376-0.550)	0.545 (0.436-0.654)	0.641 (0.499-0.774)	0.789 (0.591-0.969)	0.919 (0.668-1.14)
10-min	0.214 (0.182-0.253)	0.274 (0.235-0.327)	0.372 (0.316-0.444)	0.457 (0.385-0.548)	0.587 (0.488-0.702)	0.700 (0.572-0.837)	0.829 (0.663-0.995)	0.975 (0.760-1.18)	1.20 (0.900-1.47)	1.40 (1.02-1.73)
15-min	0.265 (0.226-0.313)	0.340 (0.291-0.406)	0.461 (0.392-0.550)	0.567 (0.478-0.679)	0.728 (0.604-0.870)	0.867 (0.709-1.04)	1.03 (0.823-1.23)	1.21 (0.942-1.46)	1.49 (1.11-1.83)	1.73 (1.26-2.15)
30-min	0.356 (0.304-0.422)	0.458 (0.392-0.546)	0.620 (0.527-0.741)	0.762 (0.643-0.914)	0.981 (0.814-1.17)	1.17 (0.955-1.40)	1.38 (1.11-1.66)	1.63 (1.27-1.97)	2.00 (1.50-2.46)	2.33 (1.70-2.89)
60-min	0.441 (0.376-0.522)	0.567 (0.485-0.676)	0.768 (0.653-0.917)	0.944 (0.796-1.13)	1.21 (1.01-1.45)	1.45 (1.18-1.73)	1.71 (1.37-2.06)	2.02 (1.57-2.43)	2.48 (1.86-3.04)	2.89 (2.10-3.58)
2-hr	0.530 (0.461-0.617)	0.666 (0.580-0.776)	0.874 (0.759-1.02)	1.06 (0.912-1.23)	1.34 (1.14-1.55)	1.58 (1.32-1.83)	1.85 (1.51-2.16)	2.15 (1.72-2.54)	2.61 (2.02-3.12)	3.01 (2.26-3.64)
3-hr	0.592 (0.523-0.679)	0.742 (0.655-0.852)	0.955 (0.841-1.10)	1.14 (0.997-1.30)	1.41 (1.22-1.62)	1.64 (1.39-1.88)	1.90 (1.59-2.19)	2.18 (1.79-2.55)	2.63 (2.09-3.15)	3.03 (2.35-3.68)
6-hr	0.737 (0.655-0.839)	0.922 (0.824-1.05)	1.18 (1.04-1.33)	1.38 (1.22-1.58)	1.68 (1.47-1.92)	1.93 (1.66-2.21)	2.20 (1.87-2.53)	2.50 (2.09-2.90)	2.96 (2.41-3.48)	3.35 (2.67-3.98)
12-hr	0.903 (0.811-1.01)	1.13 (1.01-1.27)	1.43 (1.27-1.60)	1.67 (1.48-1.88)	1.99 (1.76-2.24)	2.24 (1.96-2.54)	2.51 (2.17-2.85)	2.78 (2.38-3.19)	3.18 (2.66-3.68)	3.54 (2.91-4.14)
24-hr	1.07 (0.992-1.16)	1.34 (1.24-1.44)	1.67 (1.55-1.80)	1.94 (1.80-2.09)	2.30 (2.13-2.48)	2.58 (2.38-2.78)	2.87 (2.63-3.09)	3.17 (2.88-3.42)	3.56 (3.21-3.86)	3.87 (3.46-4.20)
2-day	1.19 (1.11-1.28)	1.49 (1.39-1.60)	1.86 (1.74-2.00)	2.16 (2.01-2.31)	2.57 (2.38-2.75)	2.88 (2.66-3.09)	3.21 (2.95-3.45)	3.54 (3.24-3.81)	3.99 (3.61-4.32)	4.34 (3.90-4.72)
3-day	1.29 (1.21-1.39)	1.62 (1.51-1.74)	2.02 (1.89-2.17)	2.34 (2.19-2.51)	2.78 (2.59-2.98)	3.13 (2.90-3.35)	3.48 (3.20-3.73)	3.84 (3.51-4.13)	4.33 (3.92-4.68)	4.71 (4.23-5.11)
4-day	1.39 (1.30-1.50)	1.74 (1.63-1.87)	2.18 (2.04-2.33)	2.53 (2.36-2.70)	3.00 (2.79-3.21)	3.37 (3.13-3.61)	3.75 (3.46-4.02)	4.14 (3.79-4.45)	4.66 (4.23-5.04)	5.07 (4.56-5.50)
7-day	1.63 (1.51-1.75)	2.03 (1.89-2.19)	2.54 (2.36-2.73)	2.94 (2.73-3.16)	3.49 (3.22-3.74)	3.90 (3.59-4.18)	4.32 (3.96-4.64)	4.74 (4.32-5.11)	5.30 (4.79-5.75)	5.73 (5.14-6.24)
10-day	1.81 (1.68-1.95)	2.27 (2.10-2.45)	2.84 (2.63-3.06)	3.29 (3.04-3.53)	3.88 (3.58-4.17)	4.32 (3.98-4.66)	4.78 (4.38-5.16)	5.23 (4.77-5.66)	5.83 (5.28-6.34)	6.28 (5.65-6.87)
20-day	2.29 (2.12-2.47)	2.88 (2.67-3.11)	3.56 (3.30-3.84)	4.07 (3.77-4.37)	4.70 (4.34-5.06)	5.16 (4.76-5.56)	5.61 (5.15-6.04)	6.03 (5.52-6.52)	6.56 (5.97-7.11)	6.93 (6.28-7.53)
30-day	2.75 (2.54-2.98)	3.45 (3.19-3.74)	4.29 (3.96-4.63)	4.91 (4.54-5.30)	5.70 (5.26-6.16)	6.28 (5.77-6.79)	6.84 (6.26-7.40)	7.38 (6.73-8.01)	8.06 (7.31-8.77)	8.55 (7.72-9.34)
45-day	3.28 (3.02-3.58)	4.13 (3.79-4.50)	5.16 (4.73-5.61)	5.92 (5.43-6.44)	6.90 (6.32-7.50)	7.62 (6.96-8.28)	8.32 (7.57-9.06)	9.00 (8.16-9.82)	9.85 (8.88-10.8)	10.5 (9.40-11.5)
60-day	3.76 (3.44-4.10)	4.73 (4.33-5.16)	5.90 (5.40-6.44)	6.76 (6.18-7.37)	7.87 (7.17-8.57)	8.67 (7.87-9.45)	9.45 (8.55-10.3)	10.2 (9.19-11.1)	11.1 (9.98-12.2)	11.8 (10.5-13.0)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Back to Top

PF graphical

Table A-4: Mountain Depths

NOAA Atlas 14, Volume 1, Version 5
Location name: Dammeron Valley, Utah, US*
Latitude: 37.2389°, Longitude: -113.7011°
Elevation: 5037 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.154 (0.130-0.184)	0.198 (0.168-0.239)	0.268 (0.225-0.322)	0.329 (0.274-0.397)	0.420 (0.345-0.507)	0.499 (0.404-0.603)	0.589 (0.468-0.714)	0.691 (0.534-0.844)	0.848 (0.632-1.05)	0.987 (0.714-1.24)
10-min	0.235 (0.199-0.281)	0.302 (0.256-0.363)	0.407 (0.343-0.491)	0.500 (0.417-0.605)	0.639 (0.526-0.772)	0.759 (0.615-0.918)	0.896 (0.712-1.09)	1.05 (0.814-1.28)	1.29 (0.962-1.60)	1.50 (1.09-1.88)
15-min	0.291 (0.247-0.348)	0.374 (0.317-0.450)	0.505 (0.425-0.609)	0.621 (0.517-0.750)	0.793 (0.651-0.958)	0.941 (0.763-1.14)	1.11 (0.882-1.35)	1.30 (1.01-1.59)	1.60 (1.19-1.98)	1.86 (1.35-2.33)
30-min	0.392 (0.332-0.468)	0.504 (0.427-0.606)	0.680 (0.572-0.820)	0.836 (0.696-1.01)	1.07 (0.877-1.29)	1.27 (1.03-1.53)	1.50 (1.19-1.81)	1.75 (1.36-2.14)	2.15 (1.61-2.67)	2.51 (1.81-3.14)
60-min	0.485 (0.411-0.580)	0.624 (0.528-0.751)	0.842 (0.709-1.01)	1.03 (0.862-1.25)	1.32 (1.09-1.60)	1.57 (1.27-1.90)	1.85 (1.47-2.25)	2.17 (1.68-2.65)	2.67 (1.99-3.31)	3.10 (2.25-3.89)
2-hr	0.577 (0.500-0.678)	0.728 (0.627-0.855)	0.953 (0.818-1.12)	1.15 (0.982-1.35)	1.45 (1.22-1.71)	1.71 (1.41-2.00)	2.00 (1.62-2.36)	2.32 (1.84-2.77)	2.81 (2.16-3.39)	3.24 (2.42-3.95)
3-hr	0.652 (0.573-0.754)	0.818 (0.716-0.945)	1.05 (0.916-1.21)	1.25 (1.08-1.44)	1.54 (1.32-1.78)	1.79 (1.51-2.08)	2.07 (1.72-2.41)	2.38 (1.94-2.79)	2.85 (2.27-3.43)	3.28 (2.55-3.99)
6-hr	0.814 (0.719-0.934)	1.02 (0.905-1.17)	1.29 (1.14-1.48)	1.52 (1.33-1.75)	1.85 (1.60-2.12)	2.12 (1.81-2.44)	2.40 (2.04-2.78)	2.73 (2.28-3.19)	3.23 (2.63-3.81)	3.65 (2.90-4.35)
12-hr	1.00 (0.897-1.13)	1.26 (1.12-1.42)	1.58 (1.41-1.79)	1.85 (1.64-2.10)	2.21 (1.94-2.50)	2.49 (2.17-2.83)	2.78 (2.40-3.19)	3.09 (2.63-3.56)	3.53 (2.95-4.10)	3.92 (3.22-4.61)
24-hr	1.20 (1.11-1.29)	1.50 (1.40-1.62)	1.88 (1.75-2.03)	2.19 (2.03-2.35)	2.60 (2.40-2.80)	2.93 (2.69-3.14)	3.26 (2.98-3.50)	3.59 (3.26-3.87)	4.05 (3.64-4.38)	4.41 (3.92-4.77)
2-day	1.35 (1.26-1.46)	1.70 (1.58-1.83)	2.13 (1.99-2.29)	2.49 (2.31-2.67)	2.97 (2.75-3.19)	3.35 (3.09-3.60)	3.74 (3.43-4.03)	4.15 (3.78-4.48)	4.71 (4.24-5.10)	5.14 (4.60-5.60)
3-day	1.49 (1.39-1.60)	1.87 (1.74-2.01)	2.36 (2.19-2.53)	2.75 (2.55-2.95)	3.28 (3.04-3.52)	3.70 (3.41-3.98)	4.14 (3.79-4.46)	4.59 (4.17-4.95)	5.20 (4.68-5.64)	5.68 (5.07-6.19)
4-day	1.63 (1.51-1.75)	2.04 (1.90-2.20)	2.58 (2.40-2.77)	3.01 (2.79-3.23)	3.59 (3.32-3.86)	4.06 (3.73-4.36)	4.53 (4.15-4.88)	5.03 (4.57-5.43)	5.69 (5.12-6.18)	6.22 (5.54-6.79)
7-day	1.93 (1.78-2.08)	2.42 (2.24-2.62)	3.06 (2.82-3.30)	3.56 (3.28-3.84)	4.25 (3.90-4.58)	4.78 (4.37-5.15)	5.32 (4.83-5.75)	5.88 (5.30-6.38)	6.63 (5.92-7.22)	7.21 (6.39-7.89)
10-day	2.16 (1.99-2.34)	2.72 (2.51-2.95)	3.43 (3.17-3.71)	3.99 (3.67-4.30)	4.73 (4.34-5.11)	5.30 (4.84-5.74)	5.88 (5.34-6.38)	6.47 (5.84-7.04)	7.25 (6.50-7.92)	7.86 (6.99-8.63)
20-day	2.78 (2.56-3.01)	3.50 (3.23-3.79)	4.36 (4.01-4.71)	4.99 (4.59-5.39)	5.79 (5.31-6.26)	6.38 (5.83-6.90)	6.95 (6.33-7.54)	7.50 (6.80-8.15)	8.21 (7.40-8.94)	8.71 (7.82-9.51)
30-day	3.36 (3.09-3.66)	4.24 (3.90-4.62)	5.30 (4.88-5.77)	6.10 (5.59-6.64)	7.12 (6.52-7.76)	7.87 (7.18-8.59)	8.62 (7.82-9.41)	9.34 (8.44-10.2)	10.3 (9.22-11.3)	11.0 (9.79-12.1)
45-day	4.02 (3.67-4.41)	5.08 (4.64-5.57)	6.38 (5.82-7.00)	7.36 (6.70-8.07)	8.63 (7.83-9.47)	9.58 (8.66-10.5)	10.5 (9.48-11.6)	11.5 (10.3-12.6)	12.7 (11.3-14.0)	13.6 (12.0-15.1)
60-day	4.64 (4.22-5.10)	5.87 (5.34-6.45)	7.38 (6.70-8.10)	8.48 (7.69-9.30)	9.90 (8.94-10.9)	10.9 (9.85-12.0)	12.0 (10.7-13.2)	13.0 (11.6-14.3)	14.3 (12.7-15.8)	15.2 (13.4-16.9)

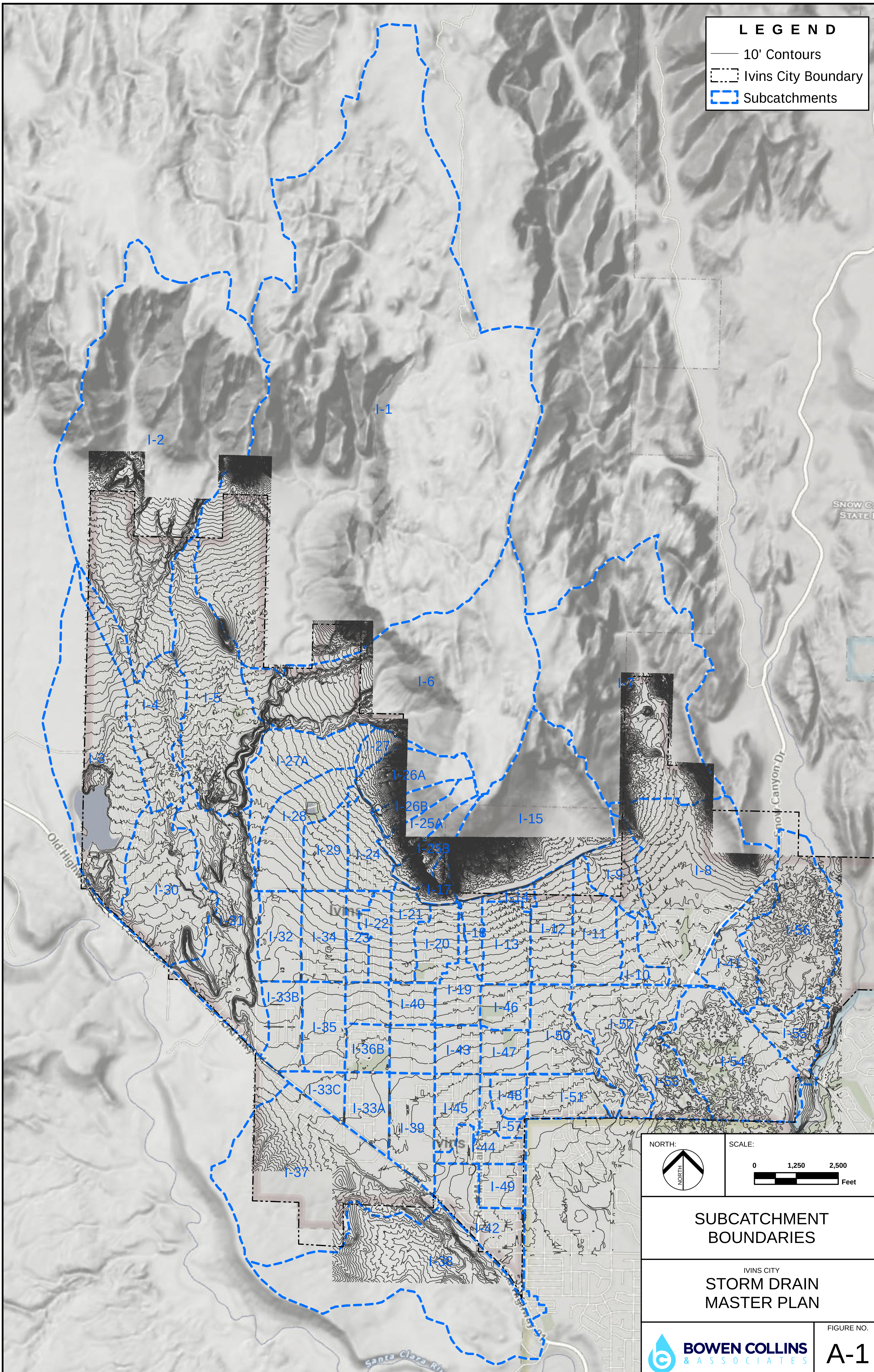
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Back to Top

PF graphical



SUBCATCHMENT BOUNDARIES

IVINS CITY

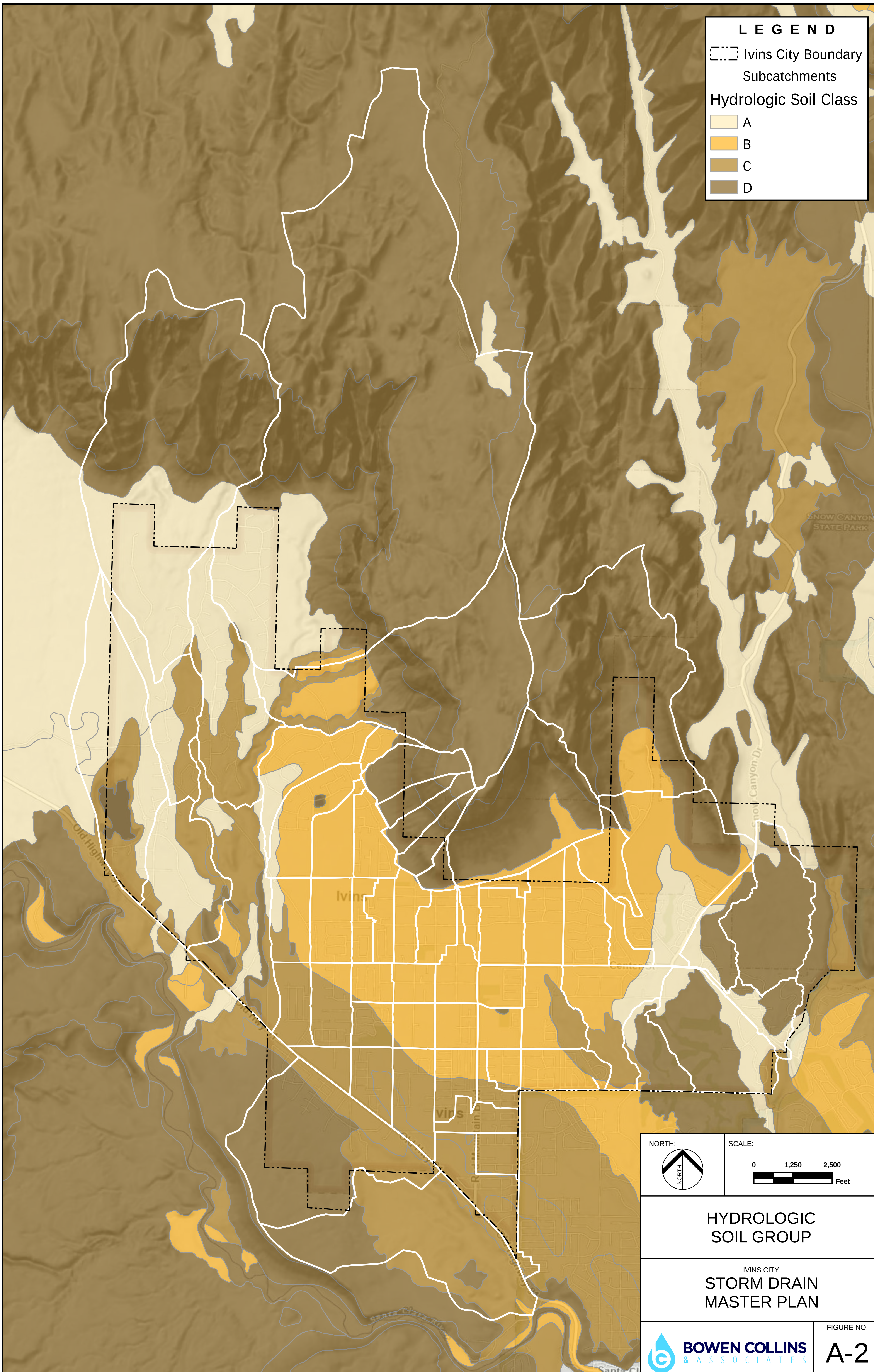
STORM DRAIN MASTER PLAN

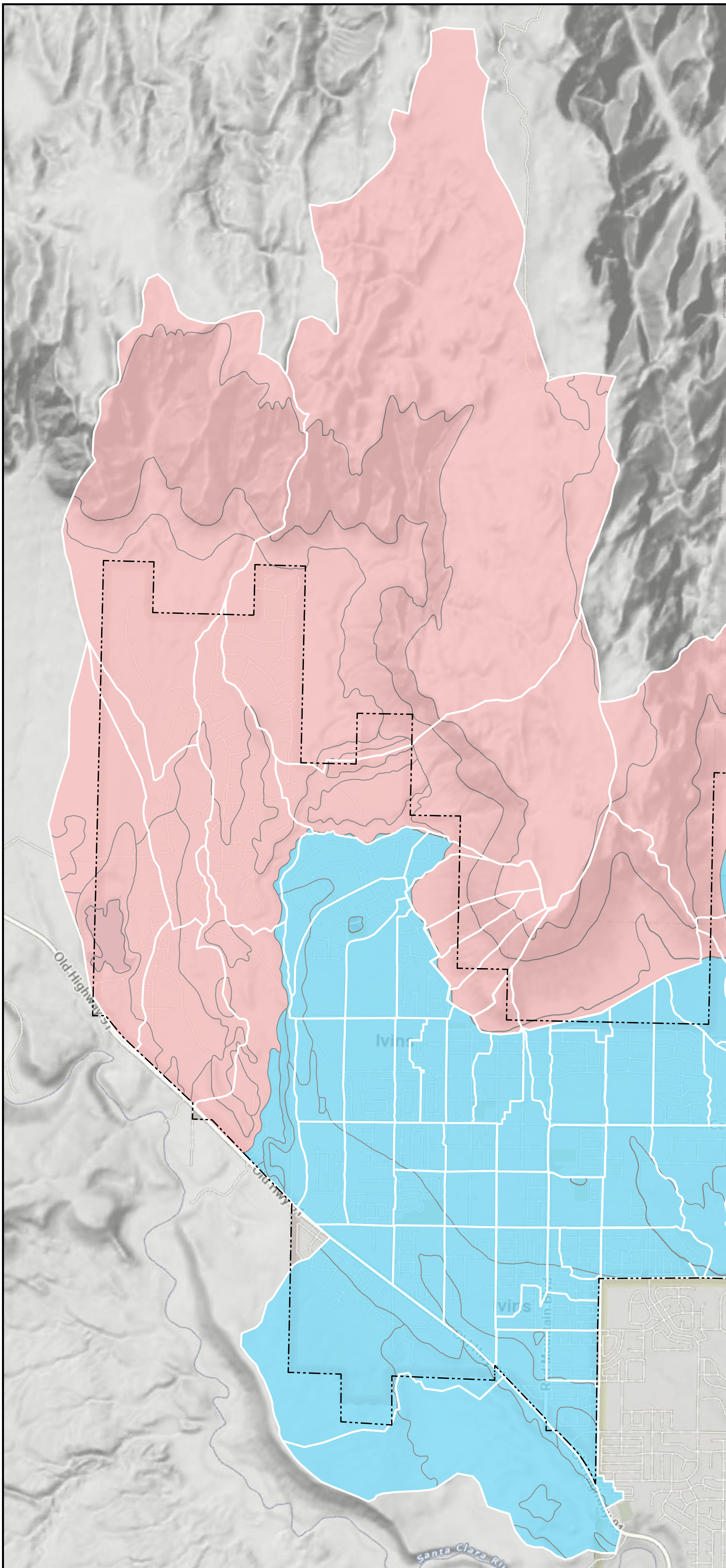
BOWEN COLLINS & ASSOCIATES

FIGURE NO.

A-1

S:\Ivins\235-22-02 Storm Drain Master Plan, IFFP, IFA, and Rate Study\4.0 GIS\4.4 APRX\Figure Projects1.aprx cmoultrie 11/6/2023


LEGEND
Ivins City Boundary
Subcatchments
Hydrologic Soil Class
A
B
C
D
Snow Canyon State Park
Snow Canyon Dr
Old Highway 91
Ivins
Center St
Santa Clara River
NORTH:
NORTH
SCALE:
0
1,250
2,500
Feet
HYDROLOGIC SOIL GROUP
IVINS CITY
STORM DRAIN MASTER PLAN
BOWEN COLLINS & ASSOCIATES
FIGURE NO.
A-2



ANTECEDENT MOISTURE CONDITION

IVINS CITY
STORM DRAIN MASTER PLAN

BOWEN COLLINS & ASSOCIATES

FIGURE NO.
A-3

S:\Ivins\235-22-02 Storm Drain Master Plan, IFFP, IFA, and Rate Study\4.0 GIS\4.4 APRX\Figure Projects1.aprx cmoultrie 11/6/2023

APPENDIX B – COST ESTIMATES

Table B-1
Conceptual Cost Estimate Unit Cost Summary
Ivins City Storm Drain Master Plan

Description	Unit	Unit Cost[1,2]
Detention Basins		
Property Acquisition	Acre	$162,600
Excavation and Hauling	Cubic Yard	$18
Landscaping (Irrigated Turfgrass)	Square Foot	$4.24
Inlet Structure	Lump Sum	$19,800
Outlet Structure	Lump Sum	$22,700
SCADA & Actuators	Lump Sum	$35,400
Emergency Spillway	Lump Sum	$7,100
Storm Drain Pipelines		
Permanent Easement Acquisition	Acre	$16,300
18-inch RCP	Linear Foot	$130
24-inch RCP	Linear Foot	$150
30-inch RCP	Linear Foot	$170
36-inch RCP	Linear Foot	$210
42-inch RCP	Linear Foot	$260
48-inch RCP	Linear Foot	$310
54-inch RCP	Linear Foot	$360
60-inch RCP	Linear Foot	$410
66-inch RCP	Linear Foot	$460
72-inch RCP	Linear Foot	$510
78-inch RCP	Linear Foot	$600
Manhole	Each	$5,700
Catch Basin	Each	$4,000
Asphalt	Square Yard	$59
Traffic Control	Linear Foot	$23
Storm Drain Culvert Road Crossings for Creeks and Washes		
Pipe Culvert	See RCP Storm Drain Costs Above	
4' X 8' Box Culvert (2-5 feet of cover)	Linear Foot	$1,200
Headwalls	Lump Sum	$6,800
Riprap	Lump Sum	$50,000
Traffic Control	Lump Sum	$7,500
Channel Construction		
Excavation and Hauling	Cubic Yard	$18
Riprap	Cubic Yard	$75
Other		
Contingency	20 Percent of Construction Cost	
Engineering, Legal, and Administration	15 Percent of Construction Cost w/ Contingency	

(1) - Costs are in 2023 Dollars
(2) - These costs were used to estimate future project costs. In some cases, detailed cost estimates provided by the City supercede these estimated costs.