Bozeman Creek Hydrologic Analysis - Bozeman Creek and Tributaries Digital Flood Insurance Rate Map Restudy Project

prepared for

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1. INTRODUCTION

1.1 Background

As part of the Mapping Activity Statement (MAS) contract for Bozeman Creek and Tributaries, in Gallatin County, Montana (**Reference 7**), RESPEC is completing a detailed floodplain study for approximately 7.9 miles of Bozeman Creek within Gallatin County, Montana. The Bozeman Creek study limits extend from the confluence with the East Gallatin River at the downstream limit to the upstream end of Nash Road at the upstream limit. The project area is displayed in **Figure 1-1**.

A Flood Insurance Study (FIS) has been completed for Gallatin County, the most recent version in 2011 (**Reference 8**). Flood hazards are currently mapped as detailed Zone AE for the entire study area of Bozeman Creek. The effective flooding for Bozeman Creek is shown in **Figure 1-2**.

The hydrologic analysis for Bozeman Creek is summarized in this report. The flood study will include the 10-, 4-, 2-, 1- and 0.2-percent-annual-chance (%AC) flood events.

1.2 Basin Description

The Bozeman Creek watershed is located within the Bozeman Creek watershed (HUC 12 100200080905) and is a left bank tributary to the East Gallatin River immediately north of Bozeman, MT. Bozeman Creek flows in a northern direction from the Gallatin National Forest towards the City of Bozeman. Bozeman Creek watershed encompasses an area of 49.5 mi^2 with the upper extents located along the divide of the Gallatin Mountain Range. The topography of the watershed ranges from mild and steep mountain slopes in the upper reaches of the watershed to a low sloping valley. The watershed is largely comprised of forested areas in the upper reaches, with the valley floor largely composed of agricultural lands such as farms and grazing pastures before the stream flows through the urbanized City of Bozeman. The soil types found throughout the watershed are predominantly classified within hydrologic soil groups B and C. The Bozeman Creek channel travels from Mystic Lake to its mouth at an average slope of approximately 100 ft/mi (1.9%).

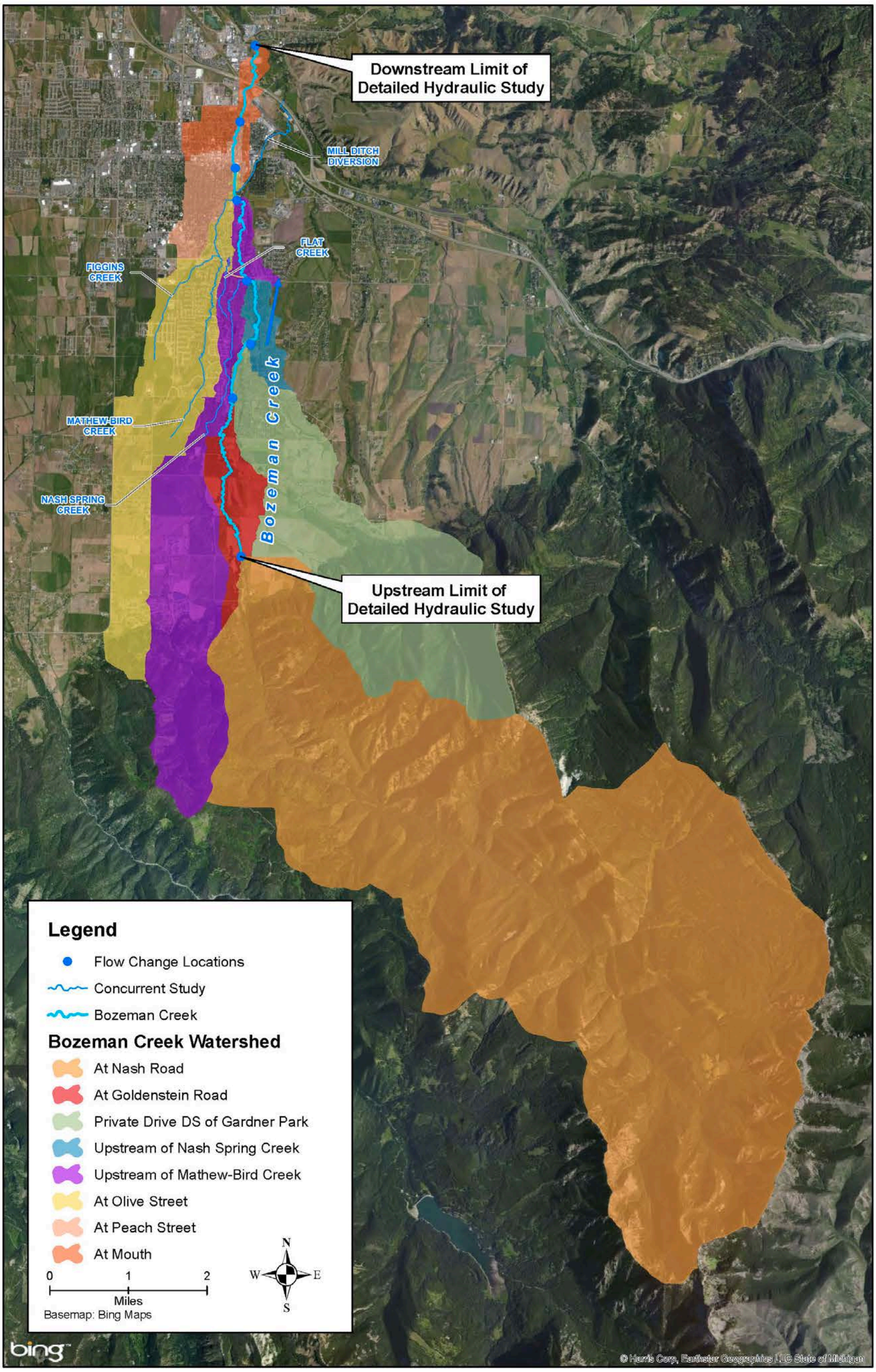

Figure 1-1. Bozeman Creek watershed

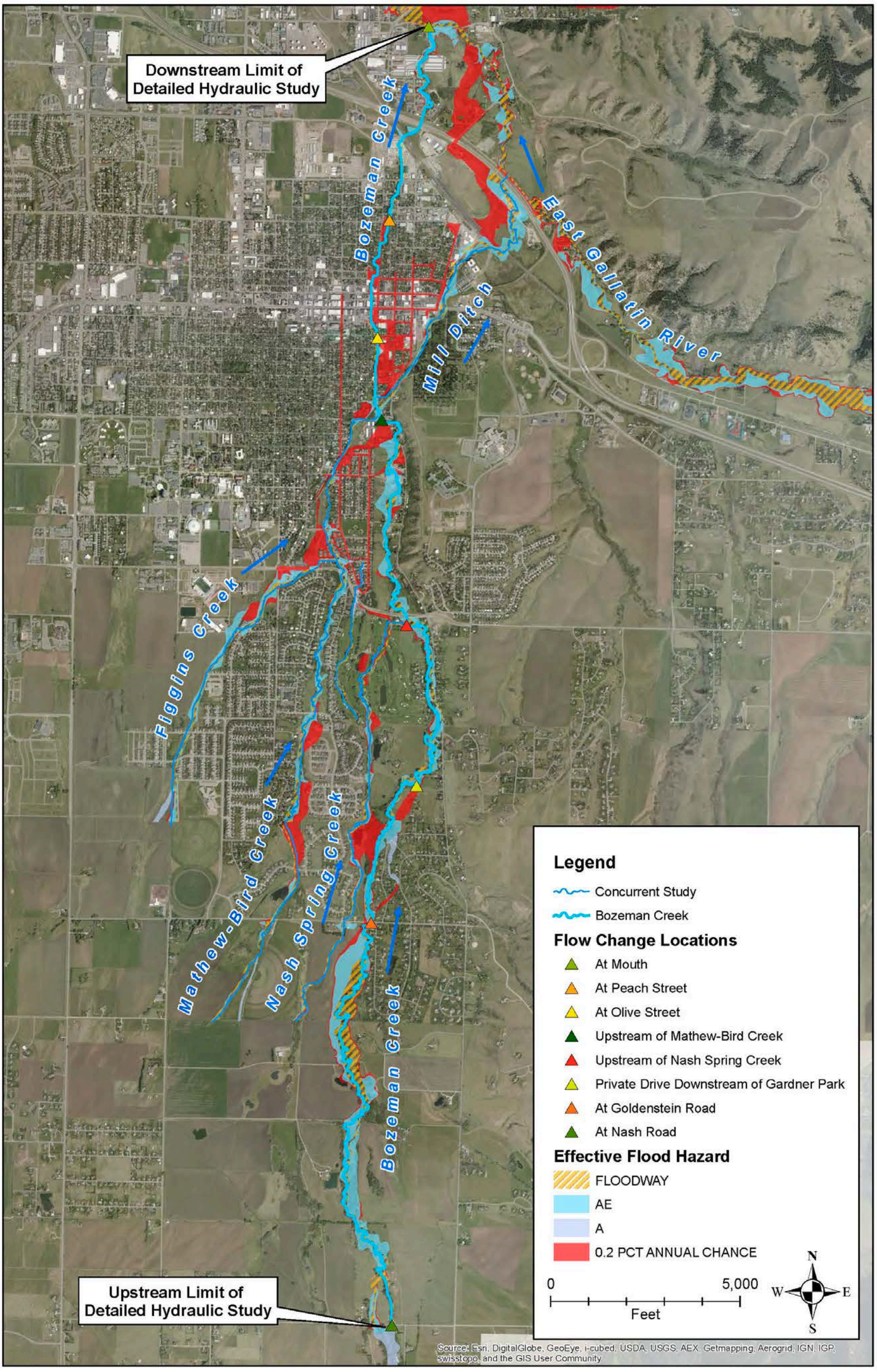

Figure 1-2. Effective flood hazard areas for Bozeman Creek

1.3 Effective Hydrologic Analysis

As previously mentioned, flood hazards are currently mapped as detailed Zone AE for the entire study area of Bozeman Creek. As detailed in the Gallatin County FIS which went effective in 2011, an original hydrologic analysis of Bozeman Creek was completed in June 1979 by the U.S. Department of Agriculture, Natural Resources Conservation Service. According to the FIS, later updates did not entail modifications to the analysis of Bozeman Creek. The effective discharges for Bozeman Creek are listed in **Table 1-1**.

Table 1-1. Effective discharges for Bozeman Creek

Location	Drainage Area* (mi^2)	10-Percent-Annual-Chance Discharge (cfs)	4-Percent-Annual-Chance Discharge (cfs)	2-Percent-Annual-Chance Discharge (cfs)	1-Percent-Annual-Chance Discharge (cfs)	0.2-Percent-Annual-Chance Discharge (cfs)
At Nash Road	30.1	405	*N/A*	642	765	1,070
At Sourdough Road	41.5	518	*N/A*	810	945	1,300
At Chicago, Milwaukee, St. Paul, and Pacific (CMSP&P) Railroad	41.9	522	*N/A*	815	950	1,320
At Story Street	49.5	600	*N/A*	920	1,070	1,455
At Interstate 90	50.4	605	*N/A*	930	1,080	1,470
At Confluence with East Gallatin River	50.9	610	*N/A*	940	1,090	1,480

**As denoted in the effective FIS (Table 4).*

1.4 Flooding History

Notable flooding within the watershed has been recorded along Bozeman Creek in April 1893, April 1948, April 1977, 1997, and most recently in May of 2011. All of these events were produced from either high rate snowmelt or rain on snow events. The FIS states that the 1948 event was the largest event with flood waters entering Bozeman (the City) causing considerable damage. Citizen accounts reference the event of May 2011 cresting to the top of the bridge on Lamme and Rouse Streets.

1.5 Other Studies

Due to its prominence within the Bozeman community, Bozeman Creek has recently been analyzed by Allied Engineering Services, Inc. (Allied) in 2012 (**Reference 1**) with the objective of developing a "hydraulic model to serve as a planning, design and permitting tool for considering opportunities and constraints for any type of channel and habitat enhancement project." Within the referenced report, Allied performed a hydrologic analysis of Bozeman Creek in which they performed a regression analysis as referenced in *Methods for Estimating Flood Frequency in Montana Based on Data through Water Year 1998: U.S. Geological Survey (USGS) Water-Resources Investigations Report (WRIR) 03-4308* (**Reference 13**). The performed analysis was based on the basin characteristics of Bozeman Creek at Interstate 90. The results of Allied's regression analysis are displayed in **Table 1-2**. It should be noted that although Allied performed their own hydrologic analysis, the results of Allied's hydraulic analysis shows that they utilized the effective discharges at Story Street as listed in **Table 1-1**.

Table 1-2. Hydrologic results of Allied Engineering Services, Inc's regression analysis

Location	10%-Annual-Chance Discharge (cfs)	4%-Annual-Chance Discharge (cfs)	2%-Annual-Chance Discharge (cfs)	1%-Annual-Chance Discharge (cfs)	0.2%-Annual-Chance Discharge (cfs)
Bozeman Creek at Interstate 90	568	796	983	1,180	1,710

The Montana Department of Transportation (MDT) was consulted in relation to previous studies within the Bozeman Creek watershed. As-built plans of Kagy Boulevard which was constructed in the 1980s were obtained and show four stream crossings through Kagy Boulevard: Middle Creek Ditch, Spring Creek, Weed Creek, and Sourdough Creek. From those plans, it is perceived that the four streams correspond to the present study streams of Figgins Creek, Mathew-Bird Creek, Flat Creek, and Bozeman Creek, respectively. The as-built plans contain a Hydraulic Data Summary for the four streams showing their station along the alignment, the type of encroachment, frequency and discharge information, and flood of record information. Both the design flood and the basic flood information correspond to the 100-yr recurrence interval flood. According to the plans, the flood of record for all streams except Figgins Creek occurred in 1973. No flood of record was identified for Figgins Creek. For Bozeman Creek (referred to as Sourdough Creek), the 100-yr discharge is reported as 1,130 cubic feet per second (cfs). No other hydrologic information was provided so their hydrologic methods and parameters utilized are unknown, complicating direct comparisons to the present study.

The City was consulted for previous study information for Bozeman Creek. Unfortunately, the City didn't have any hydrologic data concerning the 100-yr event for the watershed outside

of the previously mentioned analyses and those of recent deveopments. For development purposes the City requires that storm sewer facilities be sized for the 25-yr event and retention facilities be sized for the 10-yr 2-hr event. Since the focus of the present project is the 100-yr 24-hr event, these studies were considered negligible.

As part of the Bozeman Creek and Tributaries Project, RESPEC is simultaneously completing the hydrologic analysis of multiple tributaries within the Bozeman Creek watershed. The tributaries under analysis are Nash Spring Creek, Mathew-Bird Creek, Figgins Creek, and Flat Creek. The studies of the tributaries consisted of regression and rainfall-runoff analysis. Additional information about the analyses of the tributaries and their incorporation into the present study is further detailed in Section 2.2 and their respective reports (**References 15-18**).

2. HYDROLOGIC ANALYSES

Because no gage data is available for Bozeman Creek, regional regression equations along with a regional frequency analysis were used to calculate the peak discharges. Discharges were calculated at major road crossings and locations of significant drainage area increases. By dividing the basin at structures and locations of significant inflows, the discharges applied to upstream reaches during the hydraulic analysis are not overly conservative. For the present study, flow change locations are located at Nash Road, at Goldenstein Road, at the Private Drive just downstream of Gardner Park Drive, upstream of the Nash Spring Creek confluence, upstream of the Mathew-Bird Creek confluence, at Olive Street, at Peach Street, and at the mouth. Coincidentally, the effective FIS states that the effective discharges were also calculated at Nash Road and at the mouth (i.e. confluence with East Gallatin River). For comparison purposes, the effective flow locations of Story Street and Interstate 90 can be compared to the present flow change locations of Olive Street and the mouth, respectively.

It should be noted that there are multiple irrigation ditches present within the watershed that have the potential to distribute water to neighboring watersheds and streams. The presence of the ditches was ignored in the present analysis as the diverted discharge conveyed by these ditches would be relatively insignificant to the total flood flow of Bozeman Creek. Also, a number of these ditches are controlled by a mechanical diversion. Hence, the diversions were conservatively assumed to be closed for the present study.

2.1 Regression Analysis

The USGS historically operated a gage along Bozeman Creek in Sourdough Canyon from 1937 to 1986. However, records show that annual peaks were only recorded for two years (1952 and 1953). The Soil Conservation Service (SCS) recorded stage and discharge data along Bozeman Creek at the Kagy Boulevard (1976 – 1980) and at the Forest Service Boundary (1975 – 1977). From the SCS data, there are three recorded peak discharges (1975, 1976, and 1979). The recorded peaks of 1975 and 1976 were taken at the Forest Service Boundary while the 1979 peak was recorded at Kagy Boulevard. Although there is a history of recorded annual peaks along Bozeman Creek, it is recommended that a gaged location have at least ten years of recorded annual peaks before being included in a statistical gage analysis. The US Army Corps of Engineers report *Effective Discharge Calculation: A Practical* Guide (**Reference 3**) states that a reasonable minimum period of record for discharge calculations is roughly 10 years, with 20 years of record providing more confidence that a wide range of discharges have been captured. Since there were not enough annual peak discharges to perform a gage analysis, regression analyses were performed to compute the annual peak discharge values for specific locations along Bozeman Creek. The analyses are further detailed in the following sections.

2.1.1 Regional Regression Analysis

Regional regression equations were used to compute the annual peak discharge values for the Bozeman Creek drainage area. These equations are presented in *Methods for Estimating Flood Frequency in Montana Based on Data through Water Year 1998: U.S. Geological Survey (USGS) Water-Resources Investigations Report (WRIR) 03-4308* (**Reference 13**). USGS WRIR 03-4308 separates Montana into eight different regions based on topography and climatic conditions. The entire drainage area for Bozeman Creek is located in the Upper Yellowstone-Central Mountain Region. USGS WRIR 03-4308 provides regression equations based on basin characteristics, active-channel width, bankfull width, and various weighted combinations of the methods. It also provides the Standard Error of Prediction (SEP) for all the methods. Smaller SEP percentages point to greater reliability of the regression equations used.

Prior to using the equations, values for the regression variables were estimated. All estimated variable values for the analyzed reaches of Bozeman Creek were within the acceptable range of values used to generate the regression equations. However, the active-channel and bankfull widths measured for Bozeman Creek during field reconnaissance were largely unsuitable for the regression methods due to man-made alterations of the natural channel in the form of road crossings, development, bank protection and grade control structures. Because of this, the discharges for Bozeman Creek derived from the regional regression equations utilizing channel characteristics should be used with caution. The ranges of values used by USGS for regression equation development are presented in **Table 2-1.**

ArcGIS 10.1 was used to estimate all variables for the basin characteristics equations in a manner consistent with the methods used by the USGS to formulate the regression equations. The drainage areas (A) were delineated using digital elevation models (DEM) developed from LiDAR developed by Photo Science, Inc. (**Reference 14**) and USGS Topographic Quadrangle Maps. Drainage area delineations utilized for the regression analysis are shown in **Figure 1-1** and the values are show in **Table 2-1.**

The percentage of drainage area above elevation of 6000' (E_{6000}) was estimated by delineating the 6000' contour from the USGS Topographic Quadrangle maps. The delineated area above 6000' totals 32.0 mi^2 for the entire Bozeman Creek watershed and is shown on **Figure 2-1**. The resulting percentages of drainage area above elevation of 6000' are summarized in **Table 2-1** and calculations are included in **Appendix A**.

The active-channel width and bankfull width for all basins were measured during field reconnaissance based on guidelines presented in USGS WRIR 03-4308. These values are presented in **Table 2-1**.

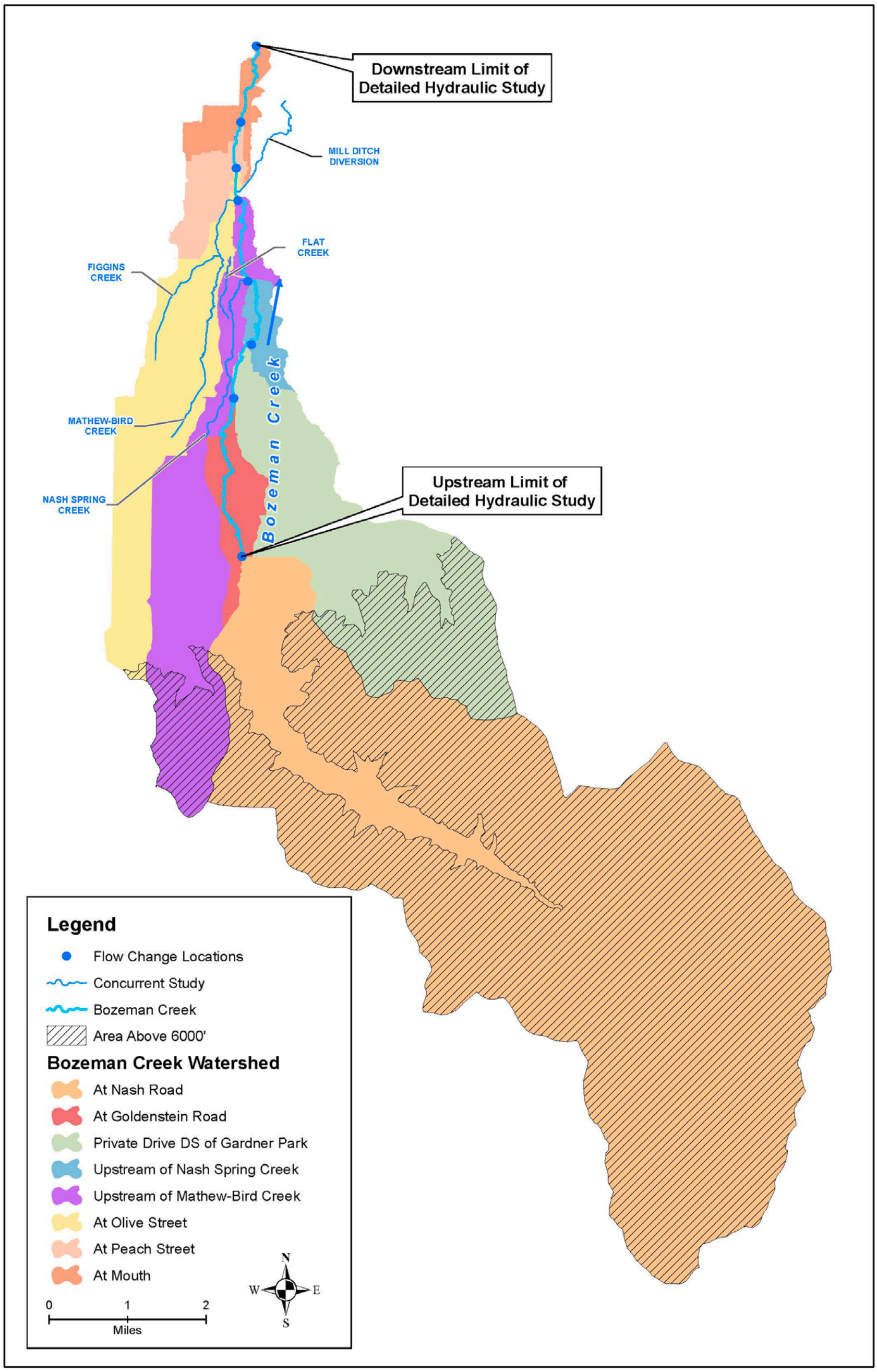

Figure 2-1. Area above elevation of 6,000' for the Bozeman Creek watershed

Table 2-1. Regression parameters

Description	Drainage Area, A (mi^2)	Percentage of basin above 6,000 feet in elevation, E_{6000} (%)	Active Channel Width W_{ac} (ft)	Bankfull Channel Width W_{bf} (ft)
Upper Yellowstone-Central Mountain Region Range of Values Used to Develop Regression Equations	0.47 - 2,032	0 - 100	1.0 - 150	2.5 - 170
At Nash Road	30.9	89.2	17.5	28.0
At Goldenstein Rd	31.9	86.4	17.0	25.0
Private Drive Downstream of Gardner Park Dr	38.8	78.7	17.5	23.5
Upstream of Nash Spring Creek	39.3	77.7	18.0	22.0
Upstream of Mathew-Bird Creek	44.0	72.5	17.8	22.5
At Olive Street	48.0	66.5	21.0	24.0
At Peach Street	48.8	65.5	18.0	26.0
At Mouth	49.5	64.6	22.0	30.0

Regression equations for basin characteristics, active-channel width, and bankfull width were used to calculate flow rates for Bozeman Creek downstream of Nash Road, at Goldenstein Road, at the Private Drive downstream of Gardner Park Drive, upstream of confluence with Nash Spring Creek, upstream of confluence with Mathew-Bird Creek, at Olive Street, at Peach Street, and at the confluence with East Gallatin River independently. A weighted combination of the three methods was also computed for the flow change locations. All calculations were performed using the web-based USGS Flood Discharge at Ungaged Sites in Montana program (**Reference 21**). The program utilizes the equations presented in WRIR 03-4308. Results of the regression analyses are included below in **Section 3** of this report and the output data from the USGS web-based program is included in **Appendix B**.

2.1.2 Regional Frequency Regression Analysis

The regression analysis performed in **Section 2.1.1** is based on the statistical regression of over 100 gaged locations spread over a wide area (Upper Yellowstone-Central Mountain Region) as shown in **Figure 2-2**. In an effort to better identify the flood discharges for Bozeman Creek, a regional frequency regression analysis was performed utilizing the gages immediately surrounding the Bozeman Creek watershed. By analyzing only those gages in the immediate area, the regression results should be more representative of the Bozeman Creek watershed.

In order to complete the regional frequency analysis, ten gaged locations located around the Bozeman Creek watershed were reviewed. The ten reviewed gages are summarized in **Table 2-2**.

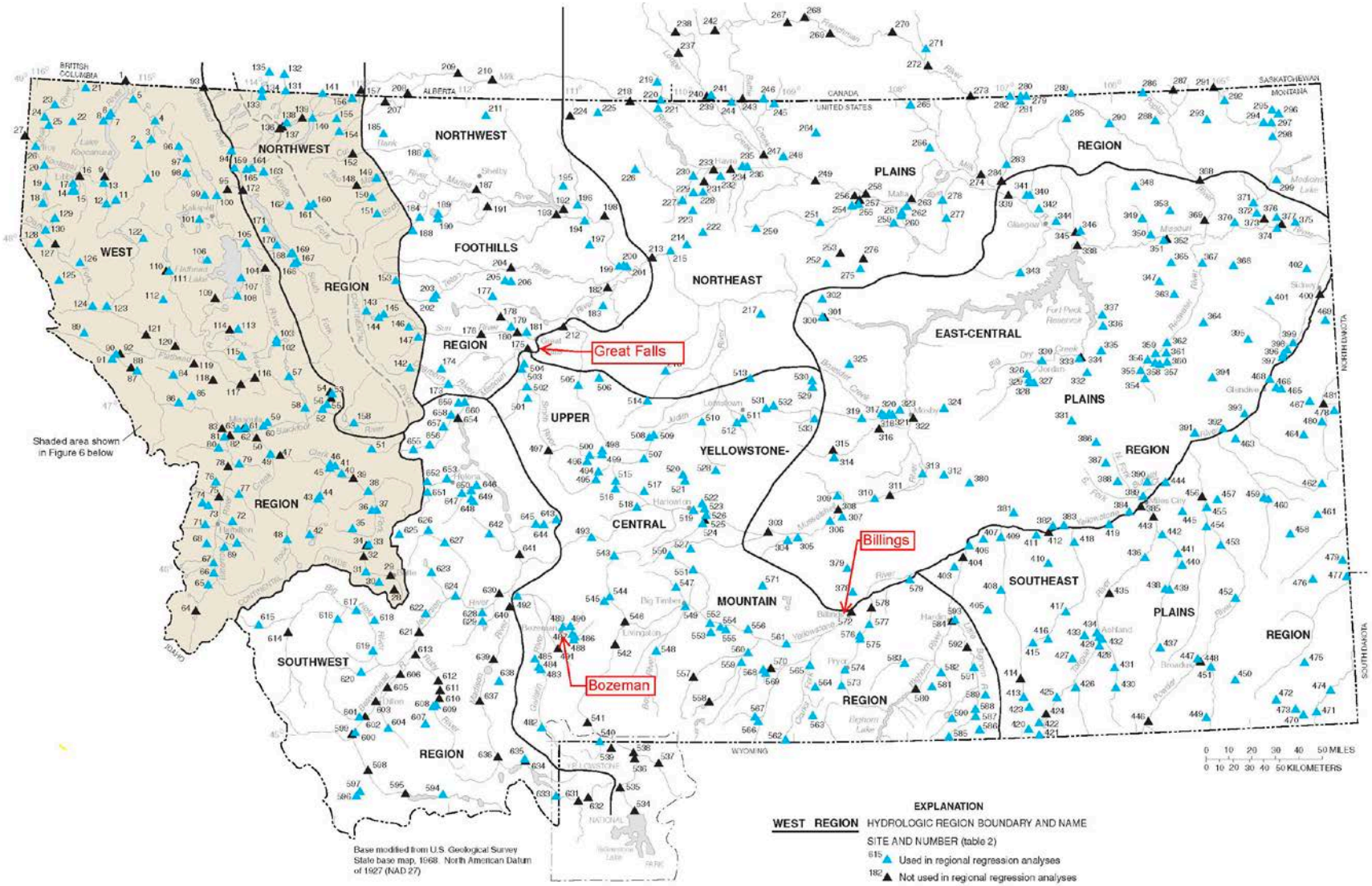

Figure 2-2. Upper Yellowstone-Central Mountain Region as defined by WRIR 03-4308

Table 2-2. Summary of gages reviewed for the regional frequency regression analysis

Station Number	Station Name	Period of Record	Number of Annual Peaks	Drainage Area (mi^2)	E_{6000} (%)
06043000	Taylor Creek near Grayling	1947 - 1967	11	98.0	99.0
06043200	Squaw Creek - Gallatin Gateway	1959 - 1975	17	37.3	98.0
06043500	Gallatin River near Salesville	1890 - Present	84	835.0	95.0
06044000	Gallatin River near Gallatin Gateway	1896 - 1923	15	833.0	95.0
06046500	Rocky Creek near Bozeman	1952 - 1991	35	50.5	55.0
06046700	Pitcher Creek near Bozeman	1960 - 1981	17	2.33	15.0
06047000	Bear Canyon near Bozeman	1952 - 1981	19	17.0	92.0
06048000	East Gallatin River near Bozeman	1940 - 1981	23	148.0	51.0
06048500	Bridger Creek near Bozeman	1946 - 1987	28	62.5	62.0
06050000	Hyalite Creek at Hyalite RS[1]	1898 - 1995	64	48.5	97.0

[1]Hyalite Creek was analyzed using the gaged record prior to the construction of the Hyalite Reservoir (1898 - 1950, 19 peaks)

After a review of the ten gaged locations it was decided to remove the Taylor Creek (06043000) gage as well as the two Gallatin River gages (06043500 and 06044000) from the analysis. The Taylor Creek and Gallatin River drainage areas were removed as they were located in a different climatic region than Bozeman Creek. Their drainages are located in the Gallatin Canyon which typically experiences a deeper snowpack and cooler temperatures which relate to a slower melt rate than that experienced in the Bozeman Creek watershed. As a result of the Taylor Creek and Gallatin River gages being removed from the analysis, a frequency analysis was performed on the seven remaining gaged locations. The locations of the seven gages utilized in the regional frequency analysis are displayed in **Figure 2-3**.

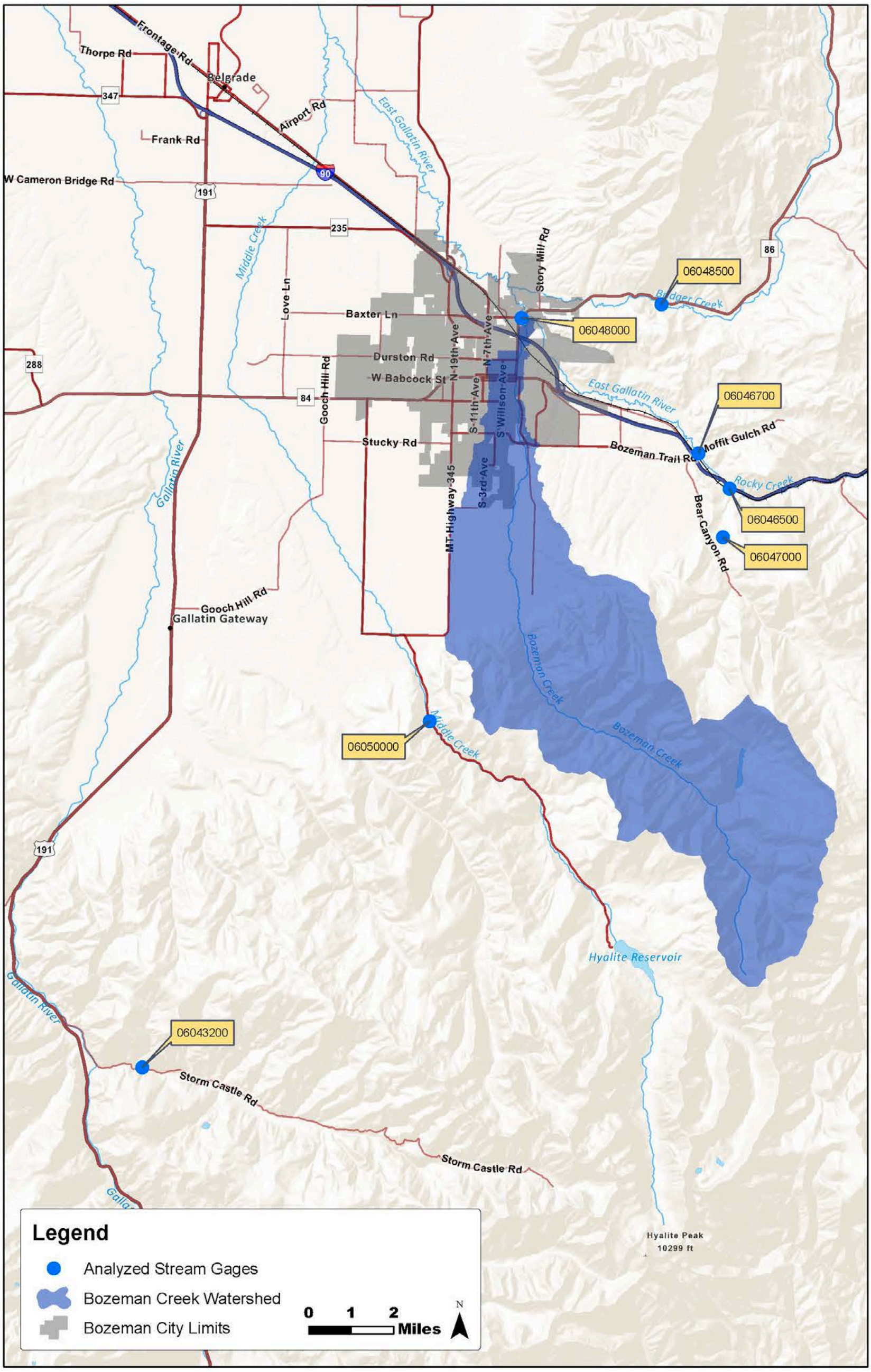

Figure 2-3. Gages utilized in the regional frequency regression analysis

All gaged locations utilized for the frequency analysis are no longer in operation and were analyzed in the aforementioned report USGS WRIR 03-4308 discussed in **Section 2.1.1**. Since the gages are no longer in operation and have not been updated since USGS WRIR 03-4308, the frequency analysis included within USGS WRIR 03-4308 was utilized for all locations except Hyalite Creek. Hyalite Creek has been regulated by a dam since 1951. Hence, as noted in **Table 2-2**, the analyzed period of record was decreased to exclude the time period that Hyalite Creek was regulated. Due to the change in analyzed annual peaks for Hyalite Creek, a gage analysis was performed to determine the annual peak discharge values. This was done following procedures outlined in Bulletin 17B (**Reference 20**) using the USGS computer program PKFQWin Version 5.2.0 (**Reference 22**). The annual peak streamflow data, taken from the USGS website in watstore format, was the input for each gage.

Prior to running PKFQWin for the decreased period of record, a calibration model was run using water years 1951 through 1995 to ensure the results of the USGS analyses could be duplicated. Montana USGS personnel were consulted to confirm the methods used for the flood frequency analysis through water year 1998. USGS confirmed that a Weighted Skew Option with a Generalized Skew Standard Error of 0.64 was used for the statistical gage analyses. Using these inputs, the results presented in USGS WRIR 03-4308 were successfully duplicated in PKFQWin, as displayed in **Table 2-3.** The PKFQWin input and output files for the baseline analysis are included in **Appendix C** with a summary of the file names listed in **Table 2-4**.

Table 2-3. Results of baseline statistical gage analysis for USGS 06050000

Frequency	USGS 03-4308 Estimated Discharge (cfs)	Baseline Estimated Discharge (cfs)
10-year	682	682
25-year	823	823
50-year	933	933
100-year	1,050	1,050
500-year	1,320	1,320

Table 2-4. Summary of file names for the baseline statistical gage analysis of USGS 06050000 (1995)

Stream Gage	File Type Description	File Name (for use in PKFQWin)
USGS 06050000 (1898 – 1995)	Data Input Files	HyaliteCreek.txt
	Baseline Analysis Specifications	Hyalite1995.psf
	Baseline Analysis Output	Hyalite1995.pdf

Upon establishment of the baseline analysis and its inherent parameters, the recorded annual peaks for 1951 – 1995 (45 years) were removed from the baseline input and a separate statistical gage analysis was performed utilizing annual peak records of 1898 - 1950. The results of the 1950 PKFQWin analysis are displayed in **Table 2-5**. The input and output files are included in **Appendix C** with a summary of the PKFQWin file names shown in **Table 2-6**.

Table 2-5. Results of 1950 statistical gage analysis for USGS 06050000

Frequency	Estimated Discharge (cfs)
10-year	647
25-year	817
50-year	956
100-year	1,110
500-year	1,510

Table 2-6. Summary of file names for the statistical gage analysis of USGS 06050000 (1950)

Stream Gage	File Type Description	File Name (for use in PKFQWin)
USGS 06050000 (1898 - 1950)	Data Input Files	HyaliteCreek.txt
	Baseline Analysis Specifications	Hyalite1950.psf
	Baseline Analysis Output	Hyalite1950.pdf

Replacing the estimated discharges of Hyalite Creek referenced in USGS WRIR 03-4308 with those of **Table 2-5**, the dataset utilized for the regional frequency regression analysis is presented in **Table 2-7** and **Figure 2-4**.

Table 2-7. Summary of data utilized for the regional frequency analysis

Location	DA (mi^2)	E_{6000} (%)	Estimated Discharge (cfs)				
			10%-AC	4%-AC	2%-AC	1%-AC	0.2%-AC
Bear Canyon Creek near Bozeman	**17.0**	**92**	309	393	458	524	682
Hyalite Creek (1898 - 1950)	**48.5**	**97**	647	817	956	1,110	1,510
Rocky Creek near Bozeman	**50.5**	**55**	748	982	1,180	1,400	2,020
Bridger Creek near Bozeman	**62.5**	**62**	637	855	1,040	1,240	1,800
East Gallatin River near Bozeman	**148.0**	**51**	1,100	1,450	1,740	2,050	2,910
Squaw Creek - Gallatin Gateway	**37.3**	**98**	496	643	764	897	1,260
Pitcher Creek near Bozeman	**2.33**	**15**	48	78	109	149	290

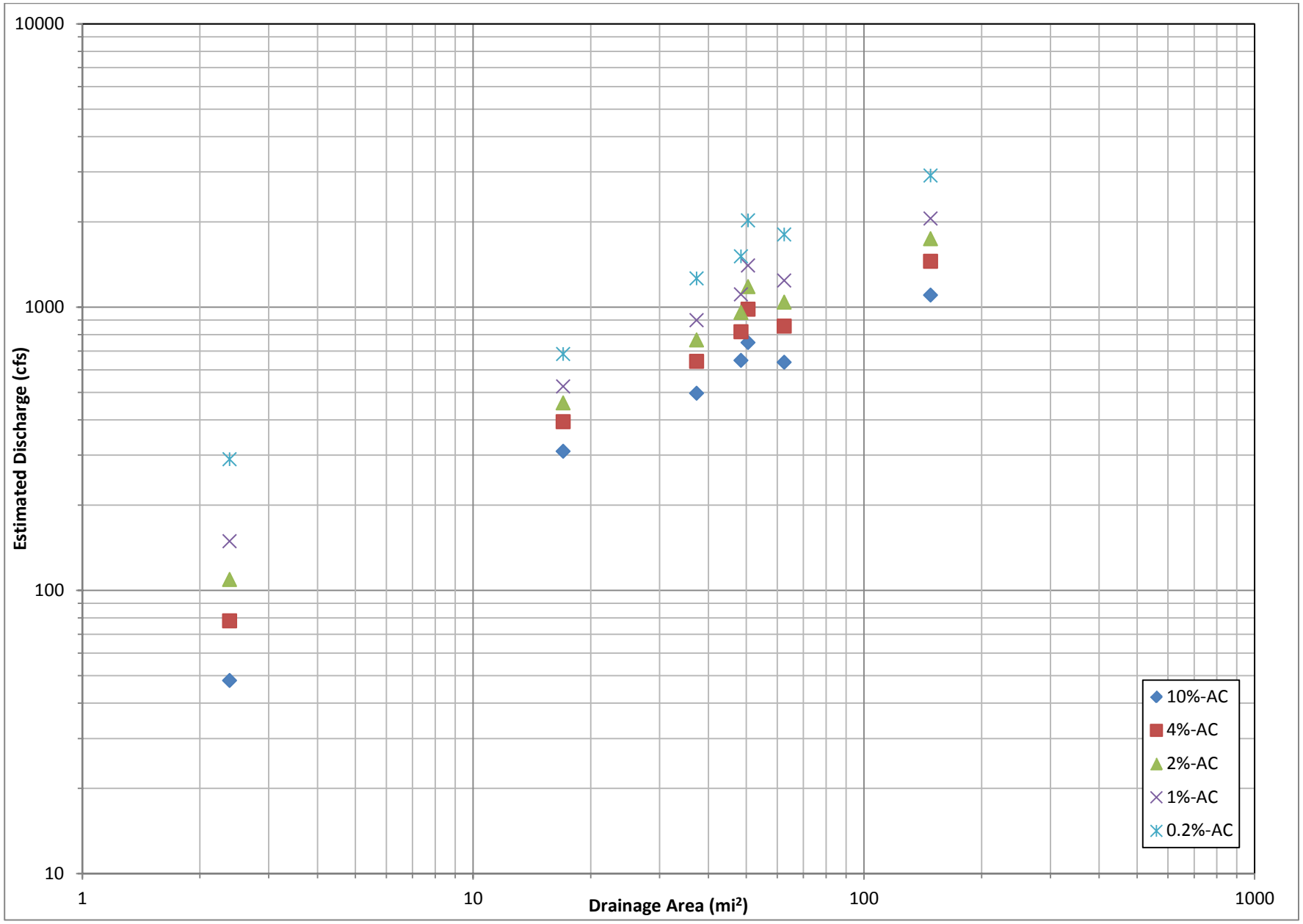

Figure 2-4. Drainage area versus discharge plot of the analyzed regional frequency dataset.

Utilizing the dataset of discharges outlined in **Table 2-7**, a single and multivariate regression analysis was performed utilizing the drainage area (A) and percentage of drainage area above elevation of 6000' (E_{6000}) parameters for each gaged location. The parameter values for each site were referenced from USGS WRIR 03-4308 and are listed in **Table 2-7**.

The single variable analysis was performed by comparing the discharge to drainage area relationship of each gaged location as shown in **Figure 2-4**. Utilizing the "Regression Analysis" tool in Microsoft Excel, the average correlation of drainage area to discharge was calculated to be 0.979. The resulting equations and calculated correlation values for the regression analysis based on drainage area are listed below in **Table 2-8**.

Table 2-8. Resultant equations and correlation of the single variable regression analysis

Event	Regression Equation	Correlation
10-year	$Q = 29.12A^{0.774}$	0.97
25-year	$Q = 46.67A^{0.723}$	0.98
50-year	$Q = 64.50A^{0.686}$	0.99
100-year	$Q = 87.25A^{0.651}$	0.99
500-year	$Q = 164.67A^{0.578}$	0.97

Similarly to the single variable regression analysis, a multivariate regression analysis was performed analyzing the relationship of drainage area and percentage of drainage area above an elevation of 6000'. The average correlation of the multivariate analysis was calculated to be 0.985. The resulting equations and calculated correlation values for the regression analysis based on drainage area and percentage of area above an elevation of 6,000' are listed below in **Table 2-9**.

Table 2-9. Resultant equations and correlation of the multivariate regression analysis

Event	Regression Equation	Correlation
10-year	$Q = 14.32A^{0.697}E_{6000}{}^{0.241}$	0.99
25-year	$Q = 31.14A^{0.679}E_{6000}{}^{0.137}$	0.99
50-year	$Q = 53.70A^{0.666}E_{6000}{}^{0.062}$	0.99
100-year	$Q = 89.47A^{0.654}E_{6000}{}^{-0.009}$	0.99
500-year	$Q = 272.47A^{0.633}E_{6000}{}^{-0.171}$	0.98

2.1.3 Urban Weighted Regression Analysis

In coincidently performed hydrologic studies along the tributaries of Bozeman Creek, an urban weighted regression analysis has been performed in order to account for the hydrologic effect of urbanization present within the watershed. However, upon review of the Bozeman Creek watershed it was decided that the urbanized area was not large enough to warrant the urban weighted analysis. In order to account for the urbanization, Sauer (**Reference 19**) states that at least 50 percent of the main drainage channels or 50 percent of the subarea (third of the watershed) is urbanized. Upon review of the watershed, the urbanized area within the watershed covers less than 50 percent of the lower subarea. Hence, the urban weighted regression analysis was not pursued further.

In combination with the relatively small level of urbanization present within the watershed, it is presumed that the less probable flood flows analyzed in the present study are produced by snowmelt often occurring in the months of April through June. The hydrologic effect of urbanization is largely attributed to the rainfall-runoff process. Given the different temporal zone of the impervious surfaces located in the City of Bozeman and that most of the watershed is considered to be saturated during the snowmelt periods, it is likely that the urbanized area would play a small to negligible role in increasing the total amount of snowmelt produced throughout the watershed.

2.2 Rainfall-Runoff Analysis

The Bozeman Creek watershed was also analyzed using the rainfall-runoff method. This was done utilizing the U.S. Army Corps of Engineers' (USACE) HEC-HMS modeling program Version 3.5. The HEC-HMS modeling program is a graphical user interface designed to simulate a precipitation-runoff response in urban or natural watersheds. The model takes into account a user specified meteorological model, loss and transform method, and reach routing method for each individual subbasin entered into the program.

As previously mentioned, the concurrent studies of Nash Spring Creek, Mathew-Bird Creek, Figgins Creek, and Flat Creek were incorporated into the Bozeman Creek analysis. In order to do so, the HEC-HMS models of the tributaries were embedded into the HEC-HMS model of Bozeman Creek. For the respective tributary basins within the Bozeman Creek HEC-HMS model, all input parameters described below are identical to the HEC-HMS model of the respective tributary to ensure consistency between the concurrent flood studies. The hydrologic analysis reports of the incorporated tributaries (**References 15-18**) contain detailed information regarding the respective tributaries of the Bozeman Creek analysis.

The meteorological model for Bozeman Creek utilized a 24-hour design storm to simulate the rainfall over the watershed. The SCS Runoff Curve Number Method was used to model potential losses. The transform method used is the Curve Number Method described in National Engineering Handbook (**Reference 11**). The Muskingum-Cunge routing method was used to route the hydrograph through the watershed. Results of the HEC-HMS model are provided in **Section 3** with input parameters discussed in the following paragraphs.

2.2.1 Precipitation

Design storms used in the hydrologic analysis of Bozeman Creek consisted of a 24-hour design storm distribution. Point precipitation depths for the 10-, 4-, 2-, and 1-percent-annual-chance storm events were taken from the isohyetal maps found in *NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, Volume I – Montana* (**Reference 9**) for durations of 6 and 24 hours. All precipitation durations less than six hours were obtained using equations, figures and tables presented in *NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, Volume I – Montana* and *Short Duration Rainfall Relations for the Western United States* (**Reference 2**). The 0.2-percent-annual-chance storm event precipitation values were extrapolated from a log-probability curve of the 10-, 4-, 2-, and 1-percent annual chance storm events. All point precipitation depths are displayed in **Table 2-10**. All pertinent data used to determine the depths are included in **Appendix D**.

Table 2-10. Design storm rainfall depths

Duration	50-Percent-Annual-Chance Depth (in)	20-Percent-Annual-Chance Depth (in)	10-Percent-Annual-Chance Depth (in)	4-Percent-Annual-Chance Depth (in)	2-Percent-Annual-Chance Depth (in)	1-Percent-Annual-Chance Depth (in)	0.2-Percent-Annual-Chance Depth (in)*
5 min	0.17	0.26	0.33	0.42	0.49	0.57	0.72
15 min	0.31	0.49	0.61	0.77	0.92	1.06	1.35
1 hr	0.45	0.72	0.91	1.13	1.34	1.54	1.94
2 hr	0.52	0.79	0.98	1.22	1.42	1.60	2.04
3 hr	0.59	0.85	1.05	1.30	1.48	1.66	2.08
6 hr	0.75	1.00	1.20	1.50	1.65	1.80	2.25
12 hr	0.94	1.26	1.53	1.88	2.09	2.25	2.81
24 hr	1.20	1.60	1.90	2.30	2.60	2.80	3.37

**0.2-percent-annual-chance precipitation depths were extrapolated from 50- to 1-percent-annual-chance depths.*

It should be noted that the utilized rainfall values were compared with the values referenced in the City of Bozeman's *Design Standards and Specifications Policy* (**Reference 5**). Comparison of the City's rainfall depths shows close correlation with the isohyetal maps found in *NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, Volume I – Montana*. However, the short duration values taken from *NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, Volume I – Montana* and *Short Duration Rainfall Relations for the Western United States* were more conservative (larger) than those estimated utilizing the City's values.

2.2.2 Loss Rate

The SCS Curve Number Method was chosen to model potential runoff loss with respect to soil type and land use conditions. In addition to the subbasins delineated for the Nash Spring Creek, Mathew-Bird Creek, Figgins Creek, and Flat Creek analyses, the remaining Bozeman Creek watershed was divided into 46 subbasins. The subbasins utilized in the hydrologic modeling of Bozeman Creek are shown in **Figure 2-5**. Drainage areas for the various subbasins are listed in **Table 2-11**.

Soils coverage for the Bozeman Creek watershed was obtained in Soil Survey Geographic (SSURGO) format from the Natural Resources Conservation Service (NRCS) Geospatial Data Gateway (**Reference 10**). The hydrologic soil groups present within the Bozeman Creek watershed are displayed in **Figure 2-6**. Review of the illustration shows that there is a large area (8.7 mi^2) in which the SSURGO dataset classified the hydrologic soil group as undefined. In order to provide a complete classification for the watershed, the undefined areas were assigned as hydrologic soil group B. This is largely due to the fact that the majority of the area

around the undefined regions was designated as hydrologic soil group B as well. The modified hydrologic soil groups are shown in **Figure 2-7**.

Land use data was also obtained from the NRCS Geospatial Data Gateway as well as the City (**Reference 6**). The land use classifications present within the Bozeman Creek watershed are displayed in **Figure 2-8**. Shapefiles containing the soils and land use data were intersected and clipped to the watershed boundary. This process resulted in a shapefile containing the land use associated to each soil type, along with the total area of each soil and land use combination within the watershed. The NRCS *Urban Hydrology for Small Watersheds Technical Release 55 (TR-55)* (**Reference 12**) was used to assign a set of curve numbers to each of the subbasins. When assigning curve numbers all areas were considered to be in good hydrologic condition with an antecedent moisture condition of two (AMCII). An on-site evaluation of the watershed was conducted in addition to the examination of aerial imagery and land use coverage. This evaluation aided in assigning the most representative set of curve numbers to the different land use and vegetative cover types present in the watershed. The adopted land use curve numbers utilized for this study are shown in **Appendix E**.

Each subbasin's cumulative loss rate was determined by calculating an areal weighted-average curve number value. This final weighted-average curve numbers for the subbasins of Bozeman Creek are shown in **Table 2-11**. Calculations for the curve number method are included in **Appendix F**.

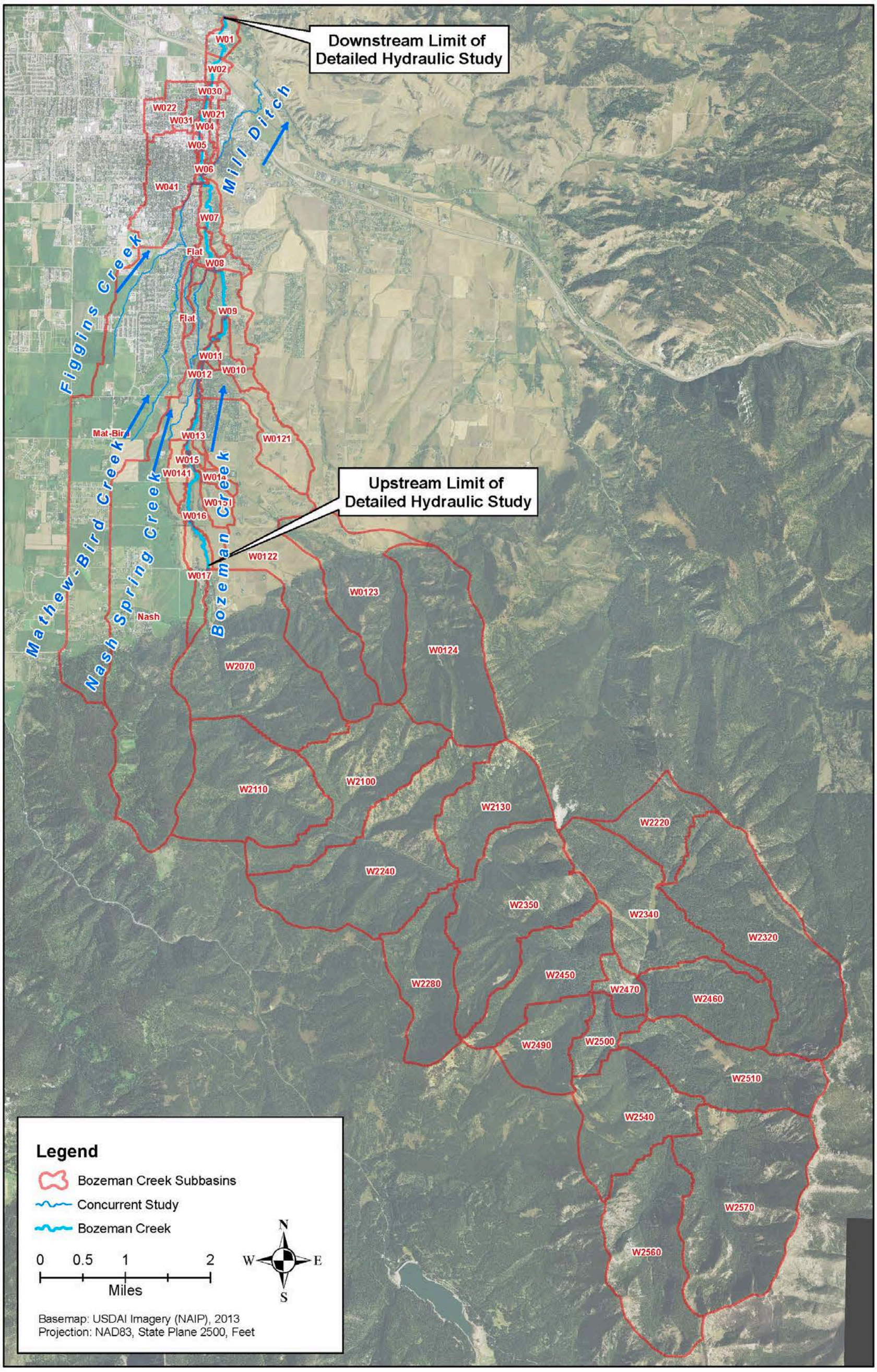

Figure 2-5. Subbasins of the Bozeman Creek hydrologic model

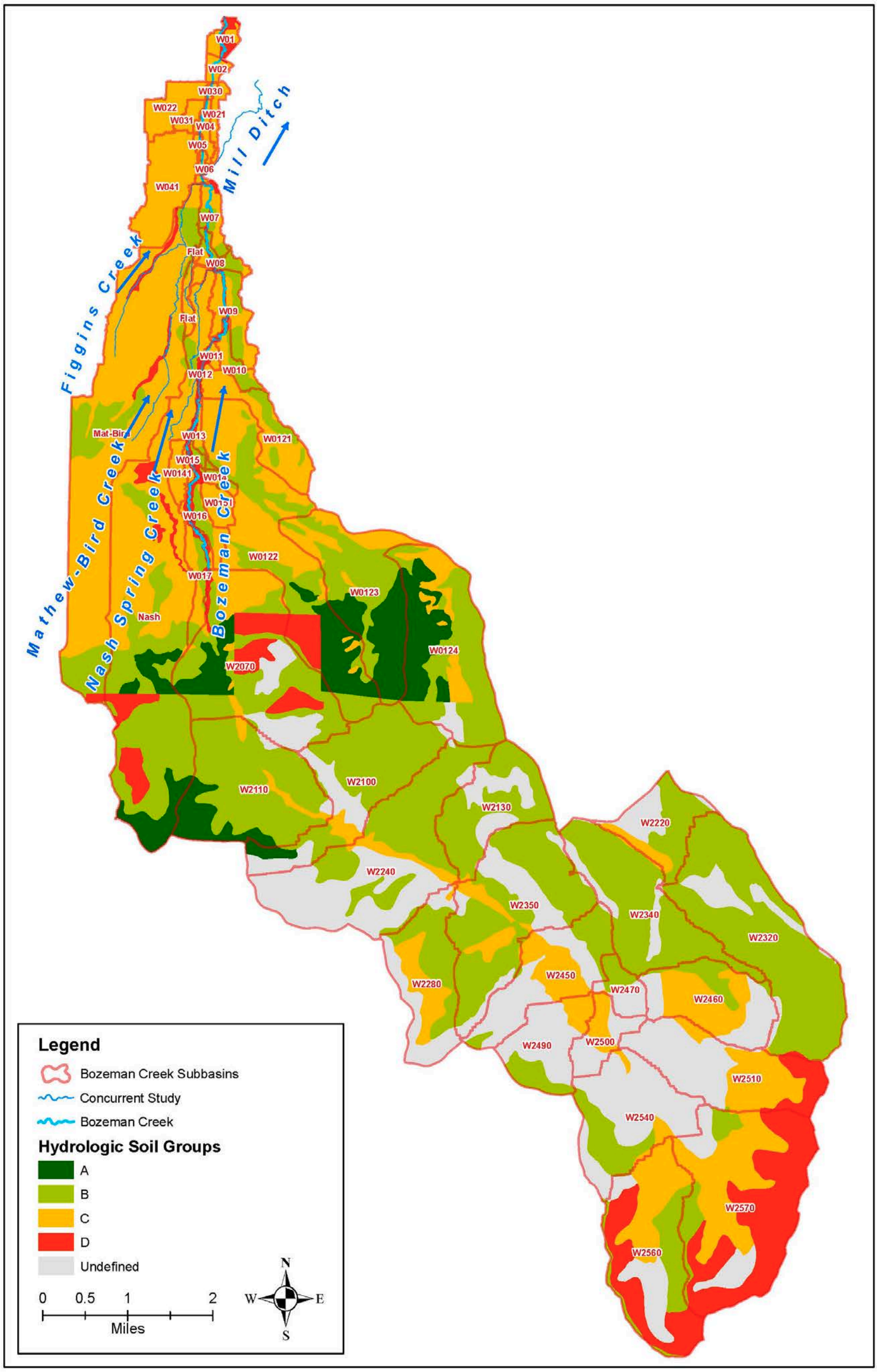

Figure 2-6. Hydrologic soil groups present within the Bozeman Creek watershed

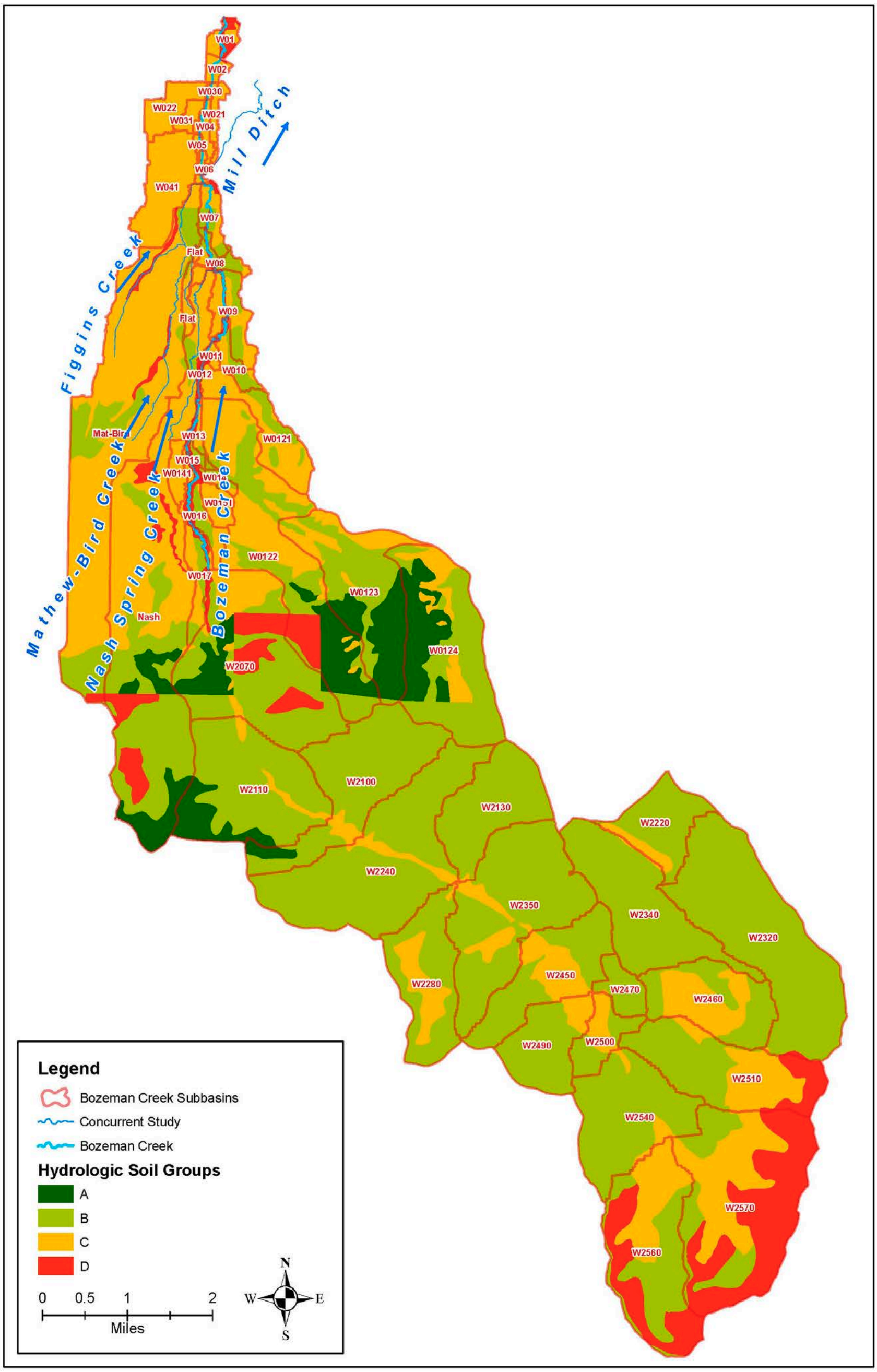

Figure 2-7. Modified hydrologic soil groups present within the Bozeman Creek watershed

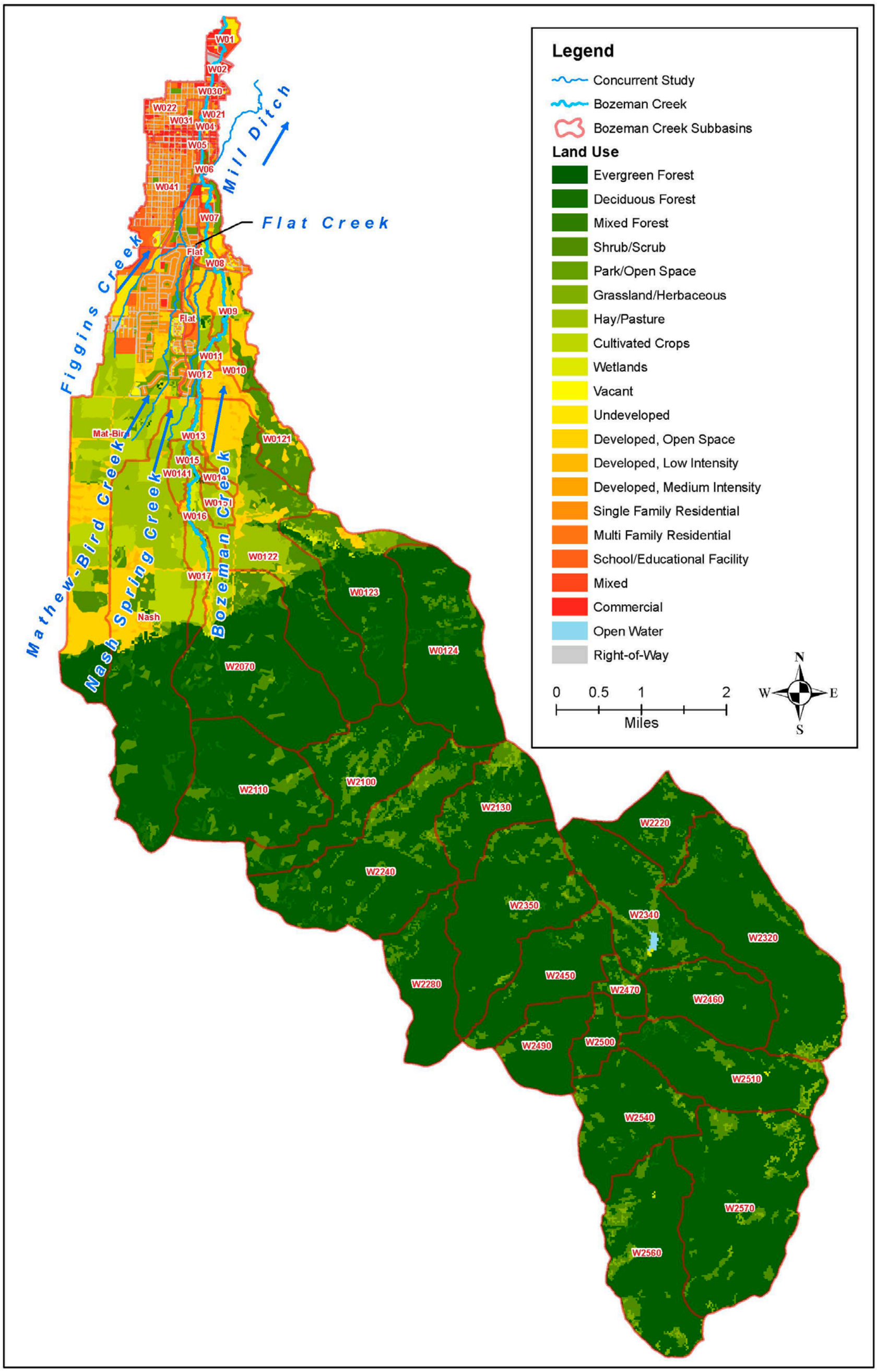

Figure 2-8. Representation of the land uses present within the Bozeman Creek watershed

2.2.3 Transform

In order to employ the SCS Dimensionless Unit Hydrograph method to distribute the runoff volume for the basin, the SCS lag time was required. The lag time for the basin was calculated using the Curve Number Lag Method described in the *National Engineering Handbook* (**Reference 11**). The lag time is calculated using the following equation:

$$L = (l^{0.8}(S+1)^{0.7}) / 1900Y^{0.5}$$

where L equals the lag time in hours; l is defined as the hydraulic length of the catchment in feet; Y represents the average watershed land slope in percent. Average watershed land slope is calculated with the equation:

$$Y = 100(CI)/A$$

where C is the summation of the length of the contour lines that pass through the watershed drainage area on the USGS quadrangle sheet in feet; I is the contour interval used on the quadrangle sheet in feet; and A is the drainage area of the basin, in square feet.

The parameter S in the Lag equation is a storage term and is defined as:

$$S = (1000 / CN) – 10$$

in which CN represents the dimensionless curve number described in **Section 2.2.2**.

Both the hydraulic length of the catchment and the average watershed land slope were calculated using ArcGIS 10.1 with the LiDAR and 10-m DEM datasets, respectively. The path of the hydraulic length for each subbasin is shown in **Figure 2-9**. The slope tool within ArcGIS calculates slope for each cell of the DEM, from which an average is then obtained. In comparisons performed in previous studies, it was discovered that the average basin slope obtained through the ArcGIS slope tool compared well to the same parameter obtained by measuring contour lines. Initial calculations of the watershed slope were performed with the LiDAR dataset, which includes many steep slopes along the channel and other small scale artificial topographic features such as building footprints. The method for calculating lag time and time of concentration was developed with topography from USGS quadrangle maps utilizing the length of contour lines and contour interval within the basin. The topography shown on those maps is the same dataset as the USGS 10-m DEM. Therefore, the USGS 10-m DEM dataset was used for the average basin slope calculation to better align with how the method was developed.

HEC-HMS then uses the lag time parameter to internally calculate the time of concentration (t_c) for the watershed using the following equation:

$$t_c = L / 0.6$$

The results of the described calculations are provided in Supplemental information and calculations are provided in **Appendix G**.

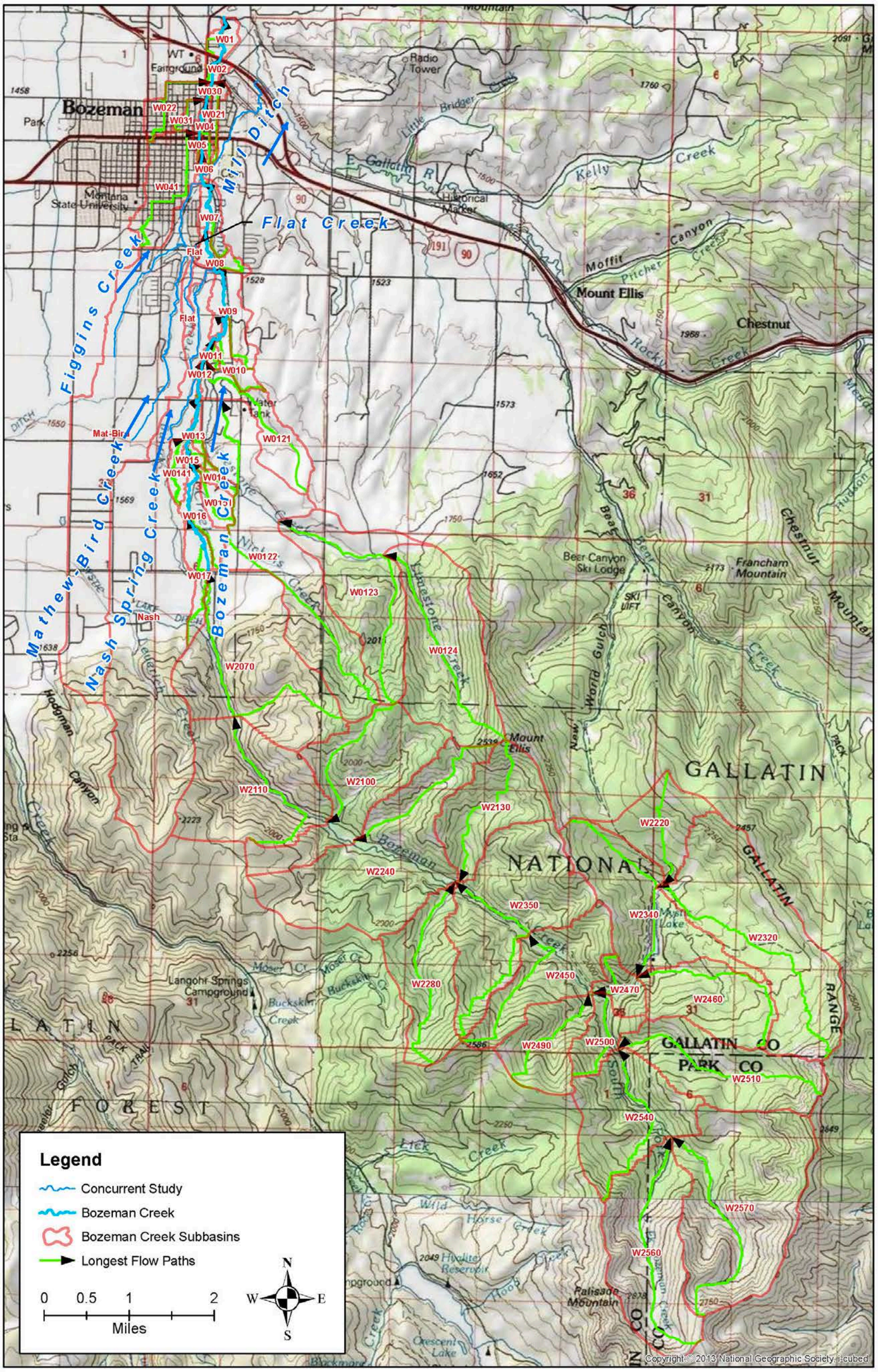

Figure 2-9. Longest flow paths utilized for the Bozeman Creek hydrologic model

Table 2-11. Summary of hydrologic parameters for each basin

Basin	Area (mi^2)	Composite CN	Hydraulic Length (ft)	Average Watershed Land Slope (%)	Lag (min)	Tc (min)
W01	0.13	89.7	3899.4	2.9	23.7	39.5
W010	0.17	65.2	9193.8	10.2	53.4	89.0
W011	0.05	75.6	2836.0	2.1	34.7	57.8
W012	0.02	78.2	3234.9	1.6	41.3	68.9
W0121	0.62	65.7	12691.9	9.4	71.2	118.7
W0122	2.52	59.8	26931.0	21.3	100.1	166.8
W0123	1.65	48.7	18934.8	31.9	81.8	136.4
W0124	2.03	49.9	16358.0	48.4	57.3	95.5
W013	0.08	73.1	7847.6	2.0	85.8	143.0
W014	0.11	68.1	7344.6	2.5	82.9	138.2
W0141	0.13	74.6	6327.1	1.5	78.8	131.4
W015	0.01	77.4	1310.4	2.8	15.3	25.5
W0151	0.17	77.2	6457.1	2.7	56.0	93.4
W016	0.25	75.1	10484.1	2.6	90.2	150.3
W017	0.28	75.2	11997.0	4.4	76.2	127.0
W02	0.07	95.6	2543.3	3.6	11.4	19.1
W021	0.09	91.1	6104.2	1.4	45.9	76.4
W022	0.28	86.5	8285.7	1.5	67.7	112.9
W030	0.02	88.4	1432.9	1.4	16.1	26.8
W031	0.08	87.3	4318.9	1.2	43.7	72.9
W04	0.09	87.1	5180.6	1.4	46.9	78.2
W041	0.67	88.5	11790.7	1.9	73.5	122.5
W05	0.02	89.2	2043.4	1.5	20.2	33.7
W06	0.04	84.4	2583.5	1.5	28.6	47.7
W07	0.18	79.6	7797.6	15.1	25.7	42.9
W08	0.18	77.4	6479.2	5.6	38.8	64.6
W09	0.36	69.7	9214.2	9.0	50.6	84.3
W2070	2.57	58.1	19619.8	33.4	64.8	108.0
W2100	1.80	53.5	11577.8	39.5	43.9	73.2
W2110	2.00	50.9	14228.5	46.0	51.2	85.4
W2130	1.16	54.2	13191.3	45.2	44.7	74.6
W2220	0.75	56.5	8544.7	25.3	39.9	66.5
W2240	2.70	54.7	13079.2	38.3	47.7	79.5
W2280	1.22	58.8	15550.2	42.6	46.9	78.1
W2320	2.74	54.8	20855.6	31.4	76.3	127.2
W2340	1.65	54.7	14413.3	29.6	58.6	97.7
W2350	2.28	55.8	17769.5	47.0	53.4	89.0
W2450	1.24	59.0	12242.9	47.7	36.4	60.7
W2460	1.14	61.9	14247.6	27.4	50.3	83.9
W2470	0.28	54.2	5100.4	54.0	19.1	31.9
W2490	0.84	56.8	10543.1	49.8	33.4	55.6
W2500	0.41	60.3	8395.2	49.9	25.5	42.4
W2510	1.59	63.5	15768.4	41.5	42.5	70.8
W2540	1.52	55.4	13968.9	48.0	44.1	73.5
W2560	1.96	66.0	17318.6	52.5	38.2	63.7
W2570	3.00	70.5	17165.4	52.4	33.7	56.2

2.2.4 Routing

To computationally route the runoff hydrograph through the watershed, the Muskingum-Cunge routing method was chosen. This routing routine approximates the diffusion method, allowing the model to describe the physical nature of the basin and thus the attenuation potential. Within the HEC-HMS model the Muskingum-Cunge method allows the user to define an eight-point cross section to describe the channel and overbank geometries, roughness values, lengths and slopes for each reach. Routing reaches were delineated using ArcGIS 10.1. The eight-point channel cross sections, lengths and slopes were created for each reach of Bozeman Creek using the LiDAR topographic dataset. The Manning's n roughness values assigned within the HEC-HMS model were determined based on site visits, aerial photography, and engineering judgment. *Open Channel Hydraulics* by Ven Te Chow (**Reference 4**) provided tables of roughness coefficients for different surfaces. Assigned Manning's values throughout the simulated reaches varied from 0.040 – 0.050 for the channels to represent a meandering channel with stones and objects of variable form roughness. Manning's values of 0.040 – 0.12 were utilized in the overbanks to describe floodplains representing grasses to dense vegetation. A singled reach (R1750-1) was assigned a channel and overbank value of 0.012 to represent the paved surface of a street.

3. HYDROLOGIC ANALYSES RESULTS

3.1 Summary of Discharges

The effective discharges for Bozeman Creek are shown in **Table 3-1**. Results of the various methods described in **Section 2** are summarized in **Table 3-2** through **Table 3-9**.

Table 3-1. Effective discharges for Bozeman Creek

Location	Drainage Area* (mi^2)	10-Percent-Annual-Chance Discharge (cfs)	4-Percent-Annual-Chance Discharge (cfs)	2-Percent-Annual-Chance Discharge (cfs)	1-Percent-Annual-Chance Discharge (cfs)	0.2-Percent-Annual-Chance Discharge (cfs)
At Nash Road	30.1	405	*N/A*	642	765	1,070
At Sourdough Road	41.5	518	*N/A*	810	945	1,300
At Chicago, Milwaukee, St. Paul, and Pacific (CMSP&P) Railroad	41.9	522	*N/A*	815	950	1,320
At Story Street	49.5	600	*N/A*	920	1,070	1,455
At Interstate 90	50.4	605	*N/A*	930	1,080	1,470
At Confluence with East Gallatin River	50.9	610	*N/A*	940	1,090	1,480

**As denoted in the effective FIS (Table 4).*

Table 3-2. Resultant discharges for Bozeman Creek downstream of Nash Road

Method	Description	10%-Annual-Chance	4%-Annual-Chance	2%-Annual-Chance	1%-Annual-Chance	0.2%-Annual-Chance
2004 USGS Regional Regression Equations - Basin Characteristics	Discharge (cfs)	377	525	647	777	1,120
	SEP	62.4%	56.1%	54.8%	55.6%	63.8%
2004 USGS Regional Regression Equations - Active Channel Width	Discharge (cfs)	617	942	1,240	1,580	2,570
	SEP	68.9%	74.4%	80.5%	87.4%	107.8%
2004 USGS Regional Regression Equations - Bankfull Width	Discharge (cfs)	689	1,030	1,340	1,700	2,720
	SEP	72.3%	77.4%	83.5%	90.6%	111.6%
2004 USGS Regional Regression Equations - Weighted Basin, Active Channel & Bankfull Widths	Discharge (cfs)	474	621	722	820	1,120
	SEP	51.0%	51.6%	53.1%	55.4%	63.8%
Single Variable Regional Frequency Analysis	Discharge (cfs)	413	556	678	813	1,190
Multivariate Regional Frequency Analysis	Discharge (cfs)	460	591	698	811	1,110
HEC-HMS (HEC-HMS Element NASH RD)	Discharge (cfs)	104	351	659	963	2,037
Effective Discharge (At Nash Road)	Discharge (cfs)	405	*N/A*	642	765	1,070

Table 3-3. Resultant discharges for Bozeman Creek at Goldenstein Road

Method	Description	10%-Annual-Chance	4%-Annual-Chance	2%-Annual-Chance	1%-Annual-Chance	0.2%-Annual-Chance
2004 USGS Regional Regression Equations - Basin Characteristics	Discharge (cfs)	388	540	666	800	1,150
	SEP	62.4%	56.0%	54.7%	55.5%	63.7%
2004 USGS Regional Regression Equations - Active Channel Width	Discharge (cfs)	596	913	1,200	1,540	2,520
	SEP	68.9%	744.0%	80.5%	87.5%	107.8%
2004 USGS Regional Regression Equations - Bankfull Width	Discharge (cfs)	589	896	1,180	1,500	2,450
	SEP	72.4%	77.5%	83.6%	90.7%	111.7%
2004 USGS Regional Regression Equations - Weighted Basin, Active Channel & Bankfull Widths	Discharge (cfs)	465	620	731	840	1,150
	SEP	50.9%	51.6%	53.1%	55.3%	63.7%
Single Variable Regional Frequency Analysis	Discharge (cfs)	424	569	693	830	1,216
Multivariate Regional Frequency Analysis	Discharge (cfs)	467	602	711	829	1,138
HEC-HMS (HEC-HMS Element BC_GOLDENSTEIN RD)	Discharge (cfs)	115	346	584	918	1,934

Table 3-4. Resultant discharges for Bozeman Creek at the Private Drive just downstream of Gardner Park Drive

Method	Description	10%-Annual-Chance	4%-Annual-Chance	2%-Annual-Chance	1%-Annual-Chance	0.2%-Annual-Chance
2004 USGS Regional Regression Equations - Basin Characteristics	Discharge (cfs)	453	632	779	936	1,350
	SEP	62.2%	55.9%	54.5%	55.4%	63.5%
2004 USGS Regional Regression Equations - Active Channel Width	Discharge (cfs)	617	942	1,240	1,580	2,570
	SEP	68.9%	74.4%	80.5%	87.4%	107.8%
2004 USGS Regional Regression Equations - Bankfull Width	Discharge (cfs)	541	829	1,090	1,400	2,310
	SEP	72.4%	77.5%	83.6%	90.8%	111.8%
2004 USGS Regional Regression Equations - Weighted Basin, Active Channel & Bankfull Widths	Discharge (cfs)	505	693	833	972	1,350
	SEP	50.9%	51.4%	53.0%	55.1%	63.5%
Single Variable Regional Frequency Analysis	Discharge (cfs)	493	656	793	943	1,362
Multivariate Regional Frequency Analysis	Discharge (cfs)	523	678	806	943	1,309
HEC-HMS (HEC-HMS Element BC_PRIVATE DRIVE)	Discharge (cfs)	122	366	602	938	1,977

Table 3-5. Resultant discharges for Bozeman Creek upstream of the confluence with Nash Spring Creek

Method	Description	10%-Annual-Chance	4%-Annual-Chance	2%-Annual-Chance	1%-Annual-Chance	0.2%-Annual-Chance
2004 USGS Regional Regression Equations - Basin Characteristics	Discharge (cfs)	458	639	788	947	1,370
	SEP	62.2%	55.9%	54.5%	55.3%	63.4%
2004 USGS Regional Regression Equations - Active Channel Width	Discharge (cfs)	638	970	1,270	1,620	2,630
	SEP	68.9%	74.3%	80.5%	87.4%	107.7%
2004 USGS Regional Regression Equations - Bankfull Width	Discharge (cfs)	493	764	1,010	1,300	2,170
	SEP	72.5%	77.6%	83.7%	90.9%	111.9%
2004 USGS Regional Regression Equations - Weighted Basin, Active Channel & Bankfull Widths	Discharge (cfs)	506	697	841	984	1,370
	SEP	50.9%	51.4%	53.0%	55.1%	63.4%
Single Variable Regional Frequency Analysis	Discharge (cfs)	498	662	800	952	1,373
Multivariate Regional Frequency Analysis	Discharge (cfs)	526	683	812	951	1,323
HEC-HMS (HEC-HMS Element BC_U/S NASH SPR CRK)	Discharge (cfs)	125	365	596	908	1,921

Table 3-6. Resultant discharges for Bozeman Creek upstream of the confluence with Mathew-Bird Creek

Method	Description	10%-Annual-Chance	4%-Annual-Chance	2%-Annual-Chance	1%-Annual-Chance	0.2%-Annual-Chance
2004 USGS Regional Regression Equations - Basin Characteristics	Discharge (cfs)	502	701	865	1,040	1,500
	SEP	62.1%	55.8%	54.4%	55.2%	63.3%
2004 USGS Regional Regression Equations - Active Channel Width	Discharge (cfs)	629	959	1,260	1,600	2,610
	SEP	68.9%	74.3%	80.5%	87.4%	107.8%
2004 USGS Regional Regression Equations - Bankfull Width	Discharge (cfs)	509	785	1,040	1,340	2,210
	SEP	72.4%	77.6%	83.7%	90.9%	111.9%
2004 USGS Regional Regression Equations - Weighted Basin, Active Channel & Bankfull Widths	Discharge (cfs)	534	747	909	1,070	1,500
	SEP	50.8%	51.4%	52.9%	55.0%	63.3%
Single Variable Regional Frequency Analysis	Discharge (cfs)	545	719	866	1,026	1,467
Multivariate Regional Frequency Analysis	Discharge (cfs)	560	731	873	1,025	1,439
HEC-HMS (HEC-HMS Element BC_US M-B CREEK)	Discharge (cfs)	146	410	659	971	1,963

Table 3-7. Resultant discharges for Bozeman Creek at Olive Street

Method	Description	10%-Annual-Chance	4%-Annual-Chance	2%-Annual-Chance	1%-Annual-Chance	0.2%-Annual-Chance
2004 USGS Regional Regression Equations - Basin Characteristics	Discharge (cfs)	541	757	935	1,130	1,630
	SEP	62.0%	55.7%	54.4%	55.1%	63.2%
2004 USGS Regional Regression Equations - Active Channel Width	Discharge (cfs)	764	1,140	1,480	1,860	2,970
	SEP	68.8%	74.3%	80.4%	87.3%	107.6%
2004 USGS Regional Regression Equations - Bankfull Width	Discharge (cfs)	557	852	1,120	1,430	2,350
	SEP	72.4%	77.5%	83.6%	90.8%	111.8%
2004 USGS Regional Regression Equations - Weighted Basin, Active Channel & Bankfull Widths	Discharge (cfs)	595	820	992	1,170	1,630
	SEP	50.8%	51.3%	52.8%	54.9%	63.2%
Single Variable Regional Frequency Analysis	Discharge (cfs)	583	766	919	1,086	1,543
Multivariate Regional Frequency Analysis	Discharge (cfs)	583	766	919	1,086	1,542
HEC-HMS (HEC-HMS Element BC_OLIVE ST)	Discharge (cfs)	200	479	750	1,069	2,085
Effective Discharge (At Story Street)	Discharge (cfs)	600	*N/A*	920	1,070	1,455

Table 3-8. Resultant discharges for Bozeman Creek at Peach Street

Method	Description	10%-Annual-Chance	4%-Annual-Chance	2%-Annual-Chance	1%-Annual-Chance	0.2%-Annual-Chance
2004 USGS Regional Regression Equations - Basin Characteristics	Discharge (cfs)	548	768	949	1,140	1,650
	SEP	62.0%	55.7%	54.3%	55.1%	63.2%
2004 USGS Regional Regression Equations - Active Channel Width	Discharge (cfs)	638	970	1,270	1,620	2,630
	SEP	68.9%	74.3%	80.5%	87.4%	107.7%
2004 USGS Regional Regression Equations - Bankfull Width	Discharge (cfs)	622	941	1,230	1,560	2,540
	SEP	72.3%	77.5%	83.5%	90.7%	111.7%
2004 USGS Regional Regression Equations - Weighted Basin, Active Channel & Bankfull Widths	Discharge (cfs)	582	814	991	1,170	1,650
	SEP	50.8%	51.3%	52.8%	54.9%	63.2%
Single Variable Regional Frequency Analysis	Discharge (cfs)	590	775	929	1,097	1,557
Multivariate Regional Frequency Analysis	Discharge (cfs)	587	773	928	1,097	1,563
HEC-HMS (HEC-HMS Element BC_PEACH ST)	Discharge (cfs)	278	492	768	1,082	2,074

Table 3-9. Resultant discharges for Bozeman Creek at mouth

Method	Description	10%-Annual-Chance	4%-Annual-Chance	2%-Annual-Chance	1%-Annual-Chance	0.2%-Annual-Chance
2004 USGS Regional Regression Equations - Basin Characteristics	Discharge (cfs)	555	777	961	1,160	1,680
	SEP	62.0%	55.7%	54.3%	55.1%	63.2%
2004 USGS Regional Regression Equations - Active Channel Width	Discharge (cfs)	807	1,200	1,550	1,940	3,080
	SEP	68.8%	74.2%	80.4%	87.3%	107.6%
2004 USGS Regional Regression Equations - Bankfull Width	Discharge (cfs)	759	1,130	1,460	1,830	2,910
	SEP	72.3%	77.4%	83.4%	90.6%	111.5%
2004 USGS Regional Regression Equations - Weighted Basin, Active Channel & Bankfull Widths	Discharge (cfs)	644	866	1,030	1,200	1,680
	SEP	50.8%	51.3%	52.8%	54.9%	63.2%
Single Variable Regional Frequency Analysis	Discharge (cfs)	596	783	938	1,107	1,570
Multivariate Regional Frequency Analysis	Discharge (cfs)	591	779	936	1,107	1,580
HEC-HMS (HEC-HMS Element BC_MOUTH)	Discharge (cfs)	340	521	781	1,092	2,069
Effective Discharge (At Confluence with East Gallatin River)	Discharge (cfs)	610	*N/A*	940	1,090	1,480

3.2 Discussion and Recommended Discharges

In review of the discharges listed in **Table 3-2** through **Table 3-9**, one can see that there is a wide range in calculated discharges of those methods of the rainfall-runoff analysis and those of the regression analysis. Review of the datasets utilized within the rainfall-runoff model leads to questions concerning the reliability of the model results, especially those upstream of Nash Road. The first concern is the necessity to utilize a modified dataset to represent the soil for a large portion of the watershed. Given that the SSURGO data had a large area classified as undefined, the requirement to reclassify the data leads to the possibility of an inaccurate representation of the hydrologic characteristics of the upper watershed of Bozeman Creek. This incomplete dataset is further compounded as not only are the hydrologic losses dependent upon the soil data, but the transform (time of concentration) is as well. Another point of concern with the model's results is the drastic increase in resultant discharge from the 1-percent annual chance event to the 0.2-percent annual chance discharge. Comparison of the modeled 1-percent annual chance discharges with those of the regression show a reasonable similarity. However, comparison of the modeled 0.2-percent annual chance discharges with those of the various regression analyses performed further displays the exaggerated increase. This dramatic increase is largely due to the steep slopes and reaches found within the upper watershed resulting in a quicker time of concentration and more intense peak within the headwaters. Since the dramatic increase does not compare well with the regression analyses, it was disregarded.

One positive of the hydrologic model is that it assists in illustrating the interaction between Bozeman Creek and the various tributaries. Review of the tabulated discharges for the HMS model shows that the increase in discharge as the hydrograph moves from Nash Road to the confluence with the East Gallatin is relatively small. This is due to the peak runoff of the tributaries traveling through the system before the hydrograph peak of Bozeman Creek. This point is further illustrated in the hydrographs displayed in **Figure 3-1** and **Figure 3-2**. As Bozeman Creek passes through Goldenstein Road, it is yet to confluence with the major tributaries of the concurrent studies (Nash Spring Creek, Mathew-Bird Creek, Figgins Creek, and Flat Creek). This is evident by the single major peak shown in **Figure 3-1**. As the Bozeman Creek hydrograph moves downstream, the hydrographs of the aforementioned concurrent studies are added. As is represented in **Figure 3-2**, the double peak at the 800 – 1000 minute timeframe is largely due to the runoff realized from Mathew-Bird and Nash Spring Creek. Also displayed in the comparison of **Figure 3-1** and **Figure 3-2** is how little affect the lower third of the watershed has on the peak discharge. As shown in the results of the HMS model (**Table 3-2** through **Table 3-9**), once the hydrograph enters the City of Bozeman at approximately Olive Street (1,069 cfs), the discharge only slightly increases by the time the peak gets to the mouth (1,092 cfs). This shows that the larger volume of runoff from the lower watershed and due to the urbanization of the City has already passed through the system.

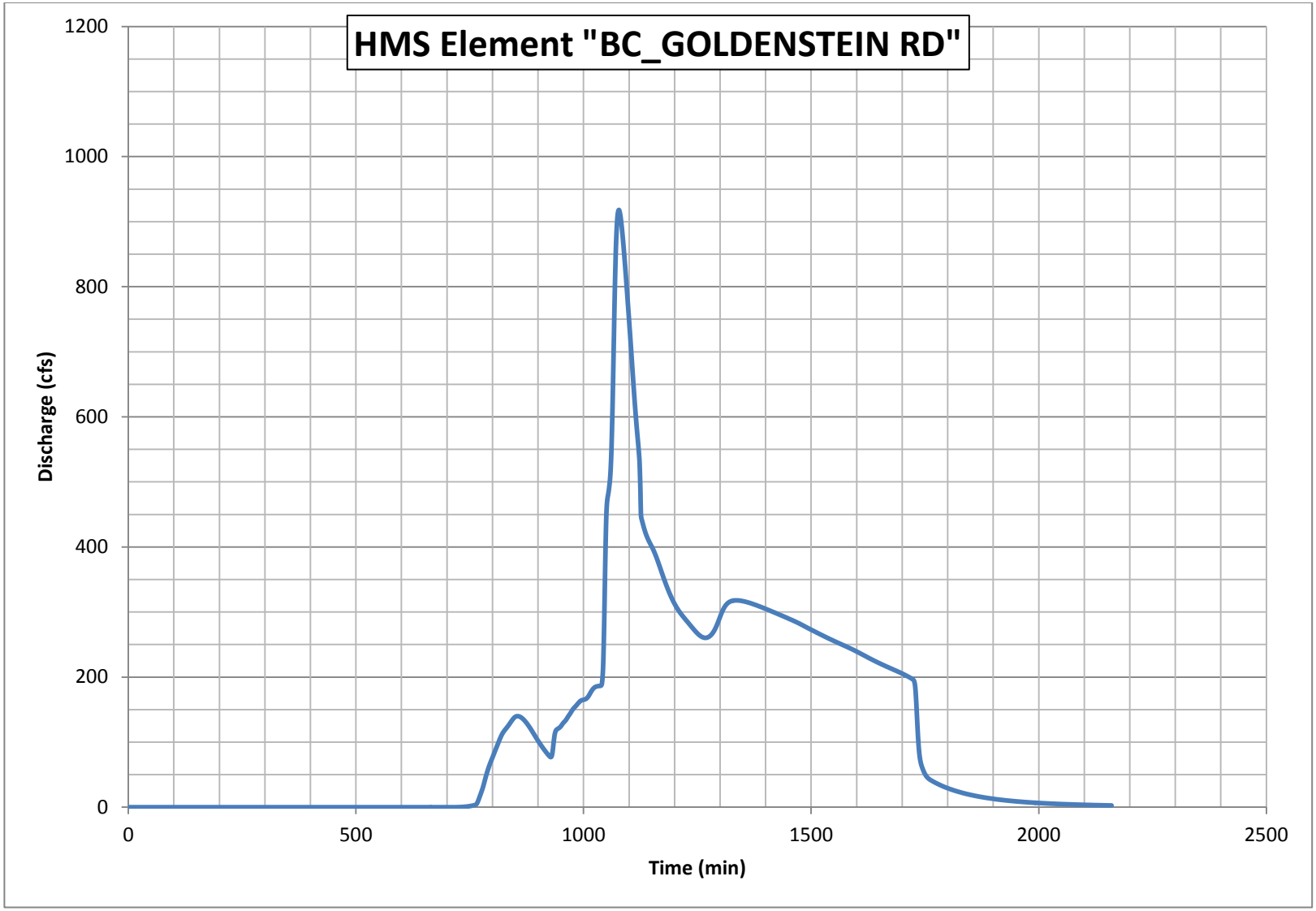

Figure 3-1. 1-percent annual chance hydrograph for Bozeman Creek at Goldenstein Road

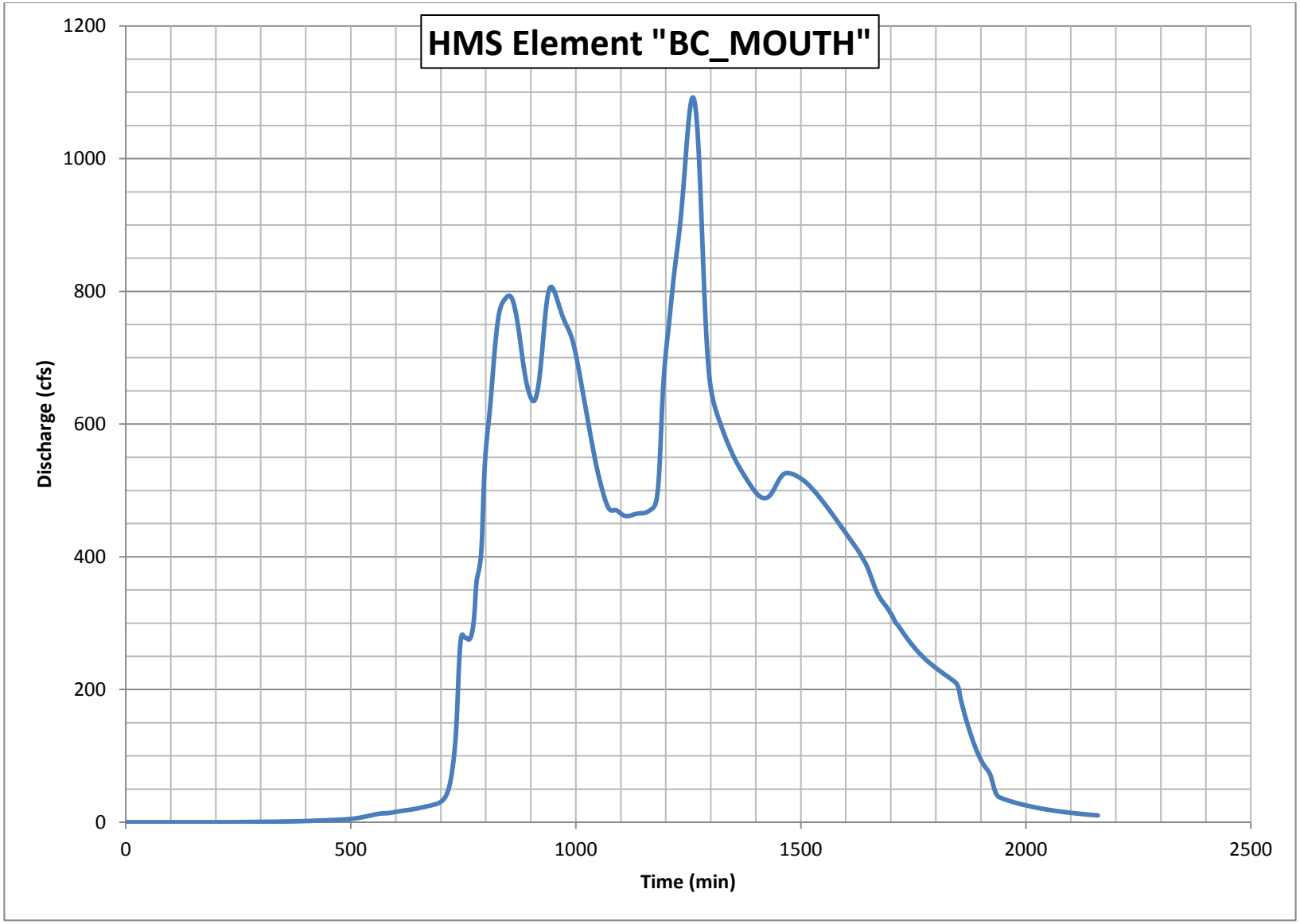

Figure 3-2. 1-percent annual chance hydrograph for the mouth of Bozeman Creek

Review of the discharges listed in **Table 3-2** through **Table 3-9** also shows that there is a large difference in the methods dependent upon basin characteristics versus those produced from channel characteristics (active-channel and bankfull widths). As previously discussed, the active-channel width and bankfull width regression equations were determined to be inappropriate due to the aforementioned man-made alterations to the natural channel. Due to this, the regression estimates utilizing the channel characteristics should be utilized for comparison purposes only. Although the weighted regression estimates provide a slightly lower SEP, it too is reliant on the channel characteristics and is therefore considered unreliable. It should be noted that other weighted regression estimates based on channel characteristics were performed. However, due to the aforementioned lack of confidence in the channel variables, the results were not displayed in the above tables. The results of all performed regression analyses can be found in **Appendix B**.

Comparison of the single variable regional frequency results with those of the multivariate regional frequency analysis shows little difference. Although the inclusion of the percentage of drainage area above elevation of 6000' parameter minimally affects the results, the correlation values of the multivariate analysis are greater than those of the single variable analysis. Hence, the multivariate regional frequency results are preferred over the single variable results based solely on drainage area.

Review of the USGS basin characteristics regression and the multivariate regional frequency analysis performed for the present study shows that the results of the two methods display a close approximation. The greatest difference in the results is found in the 10-percent-annual-chance event discharges with the multivariate regional frequency analysis being as much as 22% greater than the USGS basin characteristics regression (downstream of Nash Road). The 1-percent-annual-chance results display a variance of less than 5% for all flow change locations. Hence, choosing either method would not result in a discernable difference in the subsequent hydraulic analysis and floodplain mapping. It should also be noted that the gages utilized for the multivariate regional frequency analysis did not capture the latest events, notably the large event of 1997 which was experienced throughout the region. Many of the gages utilized for the USGS regression analysis did capture the 1997 event and are therefore thought to better represent the regression region for less frequent events. The fact that the records used in the USGS regression along with the understanding that the final product will not be that different, whether employing the results of the USGS basin characteristics regression or the multivariate regional frequency analysis, utilization of the USGS basin characteristics regression results is recommended for the hydraulic analysis as it is a widely accepted hydrologic method whose results can be easily duplicated.

Recommended 10-, 4-, 2-, 1- and 0.2-percent annual chance discharges for all locations of Bozeman Creek are presented in **Table 3-10**. These discharges are proposed for use in the hydraulic analysis of Bozeman Creek.

Table 3-10. Recommended discharges for Bozeman Creek

Location	10%-Annual-Chance Discharge (cfs)	4%-Annual-Chance Discharge (cfs)	2%-Annual-Chance Discharge (cfs)	1%-Annual-Chance Discharge (cfs)	0.2%-Annual-Chance Discharge (cfs)
At Nash Road	377	525	647	777	1,120
At Goldenstein Rd	388	540	666	800	1,150
Private Drive Downstream of Gardner Park Dr	453	632	779	936	1,350
Upstream of Nash Spring Creek	458	639	788	947	1,370
Upstream of Mathew-Bird Creek	502	701	865	1,040	1,500
At Olive Street	541	757	935	1,130	1,630
At Peach Street	548	768	949	1,140	1,650
At Mouth	555	777	961	1,160	1,680

It should be noted that the recommended discharges for the 1-percent-annual-chance events are slightly higher than the effective discharges for Bozeman Creek. Although the recommended discharges are greater, the discrepancy is likely not enough to provide a large difference in the final floodplain mapping product. Any discernable difference in the hydraulic and floodplain mapping products will likely be due to the difference in methodology or topographic data. Another difference between the recommended discharges and those of the effective values is that the effective values were results of an analysis completed in 1979. Compared to the recommended discharges the regional frequency analysis performed in 1979 has a limited period of record and does not include the noted flood event of 1997.

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APPENDIX A

PERCENTAGE OF WATERSHED ABOVE ELEVATION 6000' CALCULATIONS

Location	Drainage Area (mi2)	Area above 6000' (mi^2)	E_{6000} (%)
At Nash Road	30.9	27.5	89.2
At Goldenstein Rd	31.9	27.5	86.4
Private Drive Downstream of Gardner Park Dr	38.8	30.5	78.7
Upstream of Nash Spring Creek	39.3	30.5	77.7
Upstream of Mathew-Bird Creek	44.0	31.9	72.5
At Olive Street	48.0	32.0	66.5
At Peach Street	48.8	32.0	65.5
At Mouth	49.5	32.0	64.6

APPENDIX B

USGS REGRESSION ANALYSES

Montana Flood-Frequency and Basin-Characteristic Data

Estimate Flood Discharges at Ungaged Sites in Montana – (continued)

Summary of Estimation Parameters Selected:

Name for this estimation:	**Bozeman Creek - Nash Road**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics, Active-channel width, and Bankfull width**
Drainage area in square miles:	**30.9**
Percent basin above 6,000 feet:	**89.2**
Width of active channel in feet:	**17.5**
Width of bank full channel in feet:	**28**

Flood Discharge Estimation:

(In the Flood Discharge table, RI is the Recurrence Interval, in years; STD ERR is the Standard Error; and 90% PRED. INTERVAL is the 90% Prediction Interval, in cubic feet per second)

```
 METHOD: Regression on basin characteristics
 Flood frequency estimates for
 Bozeman Creek - Nash Road
Upper Yellowstone-Central Mountain Region: A =     30.90 E6 =    89.
 RI        DISCHARGE  STD ERR OF                90% PRED. INTERVAL
             (cfs)      PREDICTION(%)
     2        157.        94.0              42.1              590.
     5        277.        71.8              95.1              808.
    10        377.        62.4             145.6              977.
    25        525.        56.1             220.4             1250.
    50        647.        54.8             276.6             1510.
   100        777.        55.6             328.5             1840.
   200        917.        58.2             374.0             2250.
   500       1120.        63.8             424.4             2950.
```

METHOD: Regression on active channel width
Flood frequency estimates for
Bozeman Creek - Nash Road
Upper Yellowstone-Central Mountain Region: WAC = 17.50

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	192.	70.9	66.0	556.
5	412.	67.1	148.9	1140.
10	617.	68.9	217.9	1750.
25	942.	74.4	311.0	2850.
50	1240.	80.5	380.1	4030.
100	1580.	87.4	447.8	5550.
200	1970.	95.6	512.3	7560.
500	2570.	107.8	593.9	11200.

METHOD: Regression on bank full channel width
Flood frequency estimates for
Bozeman Creek - Nash Road
Upper Yellowstone-Central Mountain Region: WBF = 28.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	263.	158.8	40.4	1710.
5	469.	71.5	160.4	1370.
10	689.	72.3	233.4	2040.
25	1030.	77.4	329.0	3240.
50	1340.	83.5	398.6	4520.
100	1700.	90.6	465.3	6180.
200	2100.	99.0	528.4	8350.
500	2720.	111.6	606.7	12200.

METHOD: Combined methods 1, 2 and 3
Flood frequency estimates for
Bozeman Creek - Nash Road
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	181.	66.4	66.5	494.
5	354.	52.2	156.7	800.
10	474.	51.0	213.7	1050.
25	621.	51.6	277.2	1390.
50	722.	53.1	315.6	1650.
100	820.	55.4	347.5	1930.
200	920.	58.2	375.4	2250.
500	1120.	63.8	424.4	2950.

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Montana Flood-Frequency and Basin-Characteristic Data

Estimate Flood Discharges at Ungaged Sites in Montana – (continued)

Summary of Estimation Parameters Selected:

Name for this estimation:	**Bozeman Creek - At Goldenstein R**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics, Active-channel width, and Bankfull width**
Drainage area in square miles:	**31.9**
Percent basin above 6,000 feet:	**86.4**
Width of active channel in feet:	**17**
Width of bank full channel in feet:	**25**

Flood Discharge Estimation:

(In the Flood Discharge table, RI is the Recurrence Interval, in years; STD ERR is the Standard Error; and 90% PRED. INTERVAL is the 90% Prediction Interval, in cubic feet per second)

```
 METHOD: Regression on basin characteristics
 Flood frequency estimates for
 Bozeman Creek - At Goldenstein R
Upper Yellowstone-Central Mountain Region: A =     31.90 E6 =    86.
 RI        DISCHARGE  STD ERR OF                90% PRED. INTERVAL
             (cfs)      PREDICTION(%)
     2        161.        93.9              43.1              603.
     5        285.        71.7              97.6              829.
    10        388.        62.4             149.6             1000.
    25        540.        56.0             226.8             1290.
    50        666.        54.7             284.8             1560.
   100        800.        55.5             338.4             1890.
   200        944.        58.1             385.4             2310.
   500       1150.        63.7             437.6             3040.
```

METHOD: Regression on active channel width
Flood frequency estimates for
Bozeman Creek - At Goldenstein R
Upper Yellowstone-Central Mountain Region: WAC = 17.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	183.	70.9	63.2	532.
5	397.	67.1	143.3	1100.
10	596.	68.9	210.5	1690.
25	913.	74.4	301.6	2770.
50	1200.	80.5	369.4	3910.
100	1540.	87.5	436.0	5410.
200	1920.	95.6	499.7	7370.
500	2520.	107.8	580.4	10900.

METHOD: Regression on bank full channel width
Flood frequency estimates for
Bozeman Creek - At Goldenstein R
Upper Yellowstone-Central Mountain Region: WBF = 25.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	215.	158.8	33.0	1400.
5	395.	71.6	135.0	1160.
10	589.	72.4	199.3	1740.
25	896.	77.5	285.2	2820.
50	1180.	83.6	348.9	3970.
100	1500.	90.7	410.6	5470.
200	1870.	99.1	469.8	7440.
500	2450.	111.7	544.2	11000.

METHOD: Combined methods 1, 2 and 3
Flood frequency estimates for
Bozeman Creek - At Goldenstein R
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	177.	66.4	64.8	482.
5	342.	52.2	151.2	772.
10	465.	50.9	209.4	1030.
25	620.	51.6	277.2	1390.
50	731.	53.1	319.7	1670.
100	840.	55.3	356.3	1980.
200	947.	58.1	386.6	2320.
500	1150.	63.7	437.6	3040.

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Montana Flood-Frequency and Basin-Characteristic Data

Estimate Flood Discharges at Ungaged Sites in Montana – (continued)

Summary of Estimation Parameters Selected:

Name for this estimation:	**Bozeman Creek - Private Drive**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics, Active-channel width, and Bankfull width**
Drainage area in square miles:	**38.8**
Percent basin above 6,000 feet:	**78.7**
Width of active channel in feet:	**17.5**
Width of bank full channel in feet:	**23.5**

Flood Discharge Estimation:

(In the Flood Discharge table, RI is the Recurrence Interval, in years; STD ERR is the Standard Error; and 90% PRED. INTERVAL is the 90% Prediction Interval, in cubic feet per second)

```
 METHOD: Regression on basin characteristics
 Flood frequency estimates for
 Bozeman Creek - Private Drive
Upper Yellowstone-Central Mountain Region: A =     38.80 E6 =    79.
 RI        DISCHARGE  STD ERR OF              90% PRED. INTERVAL
             (cfs)      PREDICTION(%)
     2        188.        93.7              50.4              702.
     5        333.        71.6             114.3              967.
    10        453.        62.2             175.4             1170.
    25        632.        55.9             266.0             1500.
    50        779.        54.5             334.0             1820.
   100        936.        55.4             396.9             2210.
   200       1100.        57.9             452.1             2700.
   500       1350.        63.5             513.5             3540.
```

METHOD: Regression on active channel width
Flood frequency estimates for
Bozeman Creek - Private Drive
Upper Yellowstone-Central Mountain Region: WAC = 17.50

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	192.	70.9	66.0	556.
5	412.	67.1	148.9	1140.
10	617.	68.9	217.9	1750.
25	942.	74.4	311.0	2850.
50	1240.	80.5	380.1	4030.
100	1580.	87.4	447.8	5550.
200	1970.	95.6	512.3	7560.
500	2570.	107.8	593.9	11200.

METHOD: Regression on bank full channel width
Flood frequency estimates for
Bozeman Creek - Private Drive
Upper Yellowstone-Central Mountain Region: WBF = 23.50

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	193.	158.8	29.6	1250.
5	360.	71.6	122.8	1050.
10	541.	72.4	182.8	1600.
25	829.	77.5	263.7	2610.
50	1090.	83.6	324.3	3690.
100	1400.	90.8	383.5	5110.
200	1750.	99.2	440.6	6990.
500	2310.	111.8	512.7	10400.

METHOD: Combined methods 1, 2 and 3
Flood frequency estimates for
Bozeman Creek - Private Drive
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	191.	66.3	70.0	519.
5	365.	52.2	161.4	823.
10	505.	50.9	227.9	1120.
25	693.	51.4	310.2	1550.
50	833.	53.0	364.8	1900.
100	972.	55.1	413.3	2290.
200	1110.	57.9	452.6	2700.
500	1350.	63.5	513.5	3540.

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Montana Flood-Frequency and Basin-Characteristic Data

Estimate Flood Discharges at Ungaged Sites in Montana – (continued)

Summary of Estimation Parameters Selected:

Name for this estimation:	**BozemanCreek - US of NashSpringC**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics, Active-channel width, and Bankfull width**
Drainage area in square miles:	**39.3**
Percent basin above 6,000 feet:	**77.7**
Width of active channel in feet:	**18**
Width of bank full channel in feet:	**22**

Flood Discharge Estimation:

(In the Flood Discharge table, RI is the Recurrence Interval, in years; STD ERR is the Standard Error; and 90% PRED. INTERVAL is the 90% Prediction Interval, in cubic feet per second)

```
 METHOD: Regression on basin characteristics
 Flood frequency estimates for
 BozemanCreek - US of NashSpringC
Upper Yellowstone-Central Mountain Region: A =     39.30 E6 =    78.
 RI        DISCHARGE  STD ERR OF                90% PRED. INTERVAL
             (cfs)      PREDICTION(%)
     2        190.        93.6              50.8              709.
     5        336.        71.5             115.6              977.
    10        458.        62.2             177.4             1180.
    25        639.        55.9             269.1             1520.
    50        788.        54.5             337.9             1840.
   100        947.        55.3             401.6             2230.
   200       1120.        57.9             457.6             2730.
   500       1370.        63.4             519.9             3590.
```

METHOD: Regression on active channel width
Flood frequency estimates for
BozemanCreek - US of NashSpringC
Upper Yellowstone-Central Mountain Region: WAC = 18.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	200.	70.9	68.9	581.
5	427.	67.1	154.4	1180.
10	638.	68.9	225.3	1800.
25	970.	74.3	320.5	2940.
50	1270.	80.5	390.8	4140.
100	1620.	87.4	459.6	5690.
200	2020.	95.6	525.0	7740.
500	2630.	107.7	607.4	11400.

METHOD: Regression on bank full channel width
Flood frequency estimates for
BozemanCreek - US of NashSpringC
Upper Yellowstone-Central Mountain Region: WBF = 22.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	171.	158.9	26.3	1120.
5	325.	71.7	111.0	953.
10	493.	72.5	166.7	1460.
25	764.	77.6	242.6	2400.
50	1010.	83.7	300.1	3420.
100	1300.	90.9	356.5	4760.
200	1640.	99.3	411.3	6540.
500	2170.	111.9	481.2	9760.

METHOD: Combined methods 1, 2 and 3
Flood frequency estimates for
BozemanCreek - US of NashSpringC
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	197.	66.3	72.3	537.
5	364.	52.2	161.3	822.
10	506.	50.9	228.1	1120.
25	697.	51.4	312.0	1560.
50	841.	53.0	368.4	1920.
100	984.	55.1	418.6	2310.
200	1120.	57.9	458.1	2730.
500	1370.	63.4	519.9	3590.

Montana Flood-Frequency and Basin-Characteristic Data
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0.081

Montana Flood-Frequency and Basin-Characteristic Data

Estimate Flood Discharges at Ungaged Sites in Montana – (continued)

Summary of Estimation Parameters Selected:

Name for this estimation:	**BozemanCreek - US of MatBirdCrk**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics, Active-channel width, and Bankfull width**
Drainage area in square miles:	**44**
Percent basin above 6,000 feet:	**72.5**
Width of active channel in feet:	**17.8**
Width of bank full channel in feet:	**22.5**

Flood Discharge Estimation:

(In the Flood Discharge table, RI is the Recurrence Interval, in years; STD ERR is the Standard Error; and 90% PRED. INTERVAL is the 90% Prediction Interval, in cubic feet per second)

```
 METHOD: Regression on basin characteristics
 Flood frequency estimates for
 BozemanCreek - US of MatBirdCrk
Upper Yellowstone-Central Mountain Region: A =     44.00 E6 =    73.
 RI        DISCHARGE  STD ERR OF                90% PRED. INTERVAL
             (cfs)      PREDICTION(%)
     2        207.        93.5              55.6              772.
     5        368.        71.5             126.6             1070.
    10        502.        62.1             194.7             1300.
    25        701.        55.8             295.6             1660.
    50        865.        54.4             371.4             2020.
   100       1040.        55.2             441.7             2450.
   200       1230.        57.8             503.5             2990.
   500       1500.        63.3             572.4             3930.
```

METHOD: Regression on active channel width
Flood frequency estimates for
BozemanCreek - US of MatBirdCrk
Upper Yellowstone-Central Mountain Region: WAC = 17.80

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	197.	70.9	67.8	571.
5	421.	67.1	152.2	1170.
10	629.	68.9	222.3	1780.
25	959.	74.3	316.7	2900.
50	1260.	80.5	386.6	4090.
100	1600.	87.4	454.9	5640.
200	2000.	95.6	519.9	7670.
500	2610.	107.8	602.0	11300.

METHOD: Regression on bank full channel width
Flood frequency estimates for
BozemanCreek - US of MatBirdCrk
Upper Yellowstone-Central Mountain Region: WBF = 22.50

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	178.	158.9	27.4	1160.
5	337.	71.7	114.9	986.
10	509.	72.4	172.0	1510.
25	785.	77.6	249.6	2470.
50	1040.	83.7	308.1	3510.
100	1340.	90.9	365.5	4880.
200	1680.	99.2	421.1	6690.
500	2210.	111.9	491.7	9960.

METHOD: Combined methods 1, 2 and 3
Flood frequency estimates for
BozemanCreek - US of MatBirdCrk
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	200.	66.3	73.3	544.
5	380.	52.2	168.2	857.
10	534.	50.8	240.8	1180.
25	747.	51.4	334.3	1670.
50	909.	52.9	398.6	2070.
100	1070.	55.0	456.6	2520.
200	1230.	57.8	503.6	2990.
500	1500.	63.3	572.4	3930.

Montana Flood-Frequency and Basin-Characteristic Data
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0.035

Montana Flood-Frequency and Basin-Characteristic Data

Estimate Flood Discharges at Ungaged Sites in Montana – (continued)

Summary of Estimation Parameters Selected:

Name for this estimation:	**Bozeman Creek - At Olive Street**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics, Active-channel width, and Bankfull width**
Drainage area in square miles:	**48**
Percent basin above 6,000 feet:	**66.5**
Width of active channel in feet:	**21**
Width of bank full channel in feet:	**24**

Flood Discharge Estimation:

(In the Flood Discharge table, RI is the Recurrence Interval, in years; STD ERR is the Standard Error; and 90% PRED. INTERVAL is the 90% Prediction Interval, in cubic feet per second)

```
 METHOD: Regression on basin characteristics
 Flood frequency estimates for
 Bozeman Creek - At Olive Street
Upper Yellowstone-Central Mountain Region: A =     48.00 E6 =    67.
 RI        DISCHARGE  STD ERR OF                90% PRED. INTERVAL
             (cfs)      PREDICTION(%)
     2        221.        93.4              59.3              822.
     5        395.        71.4             136.0             1140.
    10        541.        62.0             209.8             1390.
    25        757.        55.7             319.4             1790.
    50        935.        54.4             401.9             2180.
   100       1130.        55.1             478.6             2650.
   200       1330.        57.7             546.3             3240.
   500       1630.        63.2             622.1             4260.
```

METHOD: Regression on active channel width
Flood frequency estimates for
Bozeman Creek - At Olive Street
Upper Yellowstone-Central Mountain Region: WAC = 21.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	253.	70.8	87.3	734.
5	522.	67.0	188.6	1440.
10	764.	68.8	270.2	2160.
25	1140.	74.3	377.5	3450.
50	1480.	80.4	455.0	4810.
100	1860.	87.3	529.7	6550.
200	2300.	95.5	599.6	8820.
500	2970.	107.6	686.5	12900.

METHOD: Regression on bank full channel width
Flood frequency estimates for
Bozeman Creek - At Olive Street
Upper Yellowstone-Central Mountain Region: WBF = 24.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	200.	158.8	30.7	1300.
5	371.	71.6	126.8	1090.
10	557.	72.4	188.3	1650.
25	852.	77.5	270.8	2680.
50	1120.	83.6	332.5	3780.
100	1430.	90.8	392.5	5230.
200	1790.	99.2	450.3	7140.
500	2350.	111.8	523.2	10600.

METHOD: Combined methods 1, 2 and 3
Flood frequency estimates for
Bozeman Creek - At Olive Street
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	243.	66.2	89.4	662.
5	431.	52.1	191.2	973.
10	595.	50.8	268.5	1320.
25	820.	51.3	367.3	1830.
50	992.	52.8	435.4	2260.
100	1170.	54.9	497.2	2740.
200	1330.	57.7	546.3	3240.
500	1630.	63.2	622.1	4260.

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Montana Flood-Frequency and Basin-Characteristic Data

Estimate Flood Discharges at Ungaged Sites in Montana – (continued)

Summary of Estimation Parameters Selected:

Name for this estimation:	**Bozeman Creek - At Peach Street**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics, Active-channel width, and Bankfull width**
Drainage area in square miles:	**48.8**
Percent basin above 6,000 feet:	**65.5**
Width of active channel in feet:	**18**
Width of bank full channel in feet:	**26**

Flood Discharge Estimation:

(In the Flood Discharge table, RI is the Recurrence Interval, in years; STD ERR is the Standard Error; and 90% PRED. INTERVAL is the 90% Prediction Interval, in cubic feet per second)

```
 METHOD: Regression on basin characteristics
 Flood frequency estimates for
 Bozeman Creek - At Peach Street
Upper Yellowstone-Central Mountain Region: A =     48.80 E6 =    66.
 RI        DISCHARGE  STD ERR OF                90% PRED. INTERVAL
             (cfs)      PREDICTION(%)
     2        224.        93.4              60.0              832.
     5        400.        71.4             137.9             1160.
    10        548.        62.0             212.8             1410.
    25        768.        55.7             324.1             1820.
    50        949.        54.3             407.9             2210.
   100       1140.        55.1             485.8             2690.
   200       1350.        57.7             554.6             3290.
   500       1650.        63.2             631.7             4330.
```

METHOD: Regression on active channel width
Flood frequency estimates for
Bozeman Creek - At Peach Street
Upper Yellowstone-Central Mountain Region: WAC = 18.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	200.	70.9	68.9	581.
5	427.	67.1	154.4	1180.
10	638.	68.9	225.3	1800.
25	970.	74.3	320.5	2940.
50	1270.	80.5	390.8	4140.
100	1620.	87.4	459.6	5690.
200	2020.	95.6	525.0	7740.
500	2630.	107.7	607.4	11400.

METHOD: Regression on bank full channel width
Flood frequency estimates for
Bozeman Creek - At Peach Street
Upper Yellowstone-Central Mountain Region: WBF = 26.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	230.	158.8	35.4	1500.
5	419.	71.6	143.3	1230.
10	622.	72.3	210.5	1840.
25	941.	77.5	299.7	2960.
50	1230.	83.5	365.3	4150.
100	1560.	90.7	428.8	5700.
200	1950.	99.1	489.3	7750.
500	2540.	111.7	565.1	11400.

METHOD: Combined methods 1, 2 and 3
Flood frequency estimates for
Bozeman Creek - At Peach Street
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	207.	66.3	75.9	562.
5	413.	52.1	183.1	933.
10	582.	50.8	262.7	1290.
25	814.	51.3	364.7	1820.
50	991.	52.8	435.2	2260.
100	1170.	54.9	499.0	2740.
200	1350.	57.7	554.6	3290.
500	1650.	63.2	631.7	4330.

Montana Flood-Frequency and Basin-Characteristic Data

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0.04

Montana Flood-Frequency and Basin-Characteristic Data

Estimate Flood Discharges at Ungaged Sites in Montana – (continued)

Summary of Estimation Parameters Selected:

Name for this estimation:	**Bozeman Creek - At Mouth**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics, Active-channel width, and Bankfull width**
Drainage area in square miles:	**49.5**
Percent basin above 6,000 feet:	**64.6**
Width of active channel in feet:	**22**
Width of bank full channel in feet:	**30**

Flood Discharge Estimation:

(In the Flood Discharge table, RI is the Recurrence Interval, in years; STD ERR is the Standard Error; and 90% PRED. INTERVAL is the 90% Prediction Interval, in cubic feet per second)

```
 METHOD: Regression on basin characteristics
 Flood frequency estimates for
 Bozeman Creek - At Mouth
Upper Yellowstone-Central Mountain Region: A =     49.50 E6 =    65.
 RI        DISCHARGE  STD ERR OF                90% PRED. INTERVAL
             (cfs)      PREDICTION(%)
     2        226.        93.4              60.7              841.
     5        405.        71.3             139.5             1170.
    10        555.        62.0             215.4             1430.
    25        777.        55.7             328.2             1840.
    50        961.        54.3             413.2             2240.
   100       1160.        55.1             492.2             2720.
   200       1370.        57.7             562.0             3330.
   500       1680.        63.2             640.3             4380.
```

METHOD: Regression on active channel width
Flood frequency estimates for
Bozeman Creek - At Mouth
Upper Yellowstone-Central Mountain Region: WAC = 22.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	272.	70.8	93.7	788.
5	554.	67.0	200.4	1530.
10	807.	68.8	285.5	2280.
25	1200.	74.2	396.6	3630.
50	1550.	80.4	476.3	5030.
100	1940.	87.3	552.8	6830.
200	2390.	95.5	624.0	9170.
500	3080.	107.6	712.3	13300.

METHOD: Regression on bank full channel width
Flood frequency estimates for
Bozeman Creek - At Mouth
Upper Yellowstone-Central Mountain Region: WBF = 30.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	297.	158.7	45.6	1930.
5	521.	71.5	178.2	1520.
10	759.	72.3	257.0	2240.
25	1130.	77.4	358.9	3540.
50	1460.	83.4	432.2	4900.
100	1830.	90.6	502.0	6660.
200	2250.	98.9	567.4	8960.
500	2910.	111.5	648.1	13100.

METHOD: Combined methods 1, 2 and 3
Flood frequency estimates for
Bozeman Creek - At Mouth
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	258.	66.2	94.7	701.
5	475.	52.1	210.7	1070.
10	644.	50.8	290.7	1430.
25	866.	51.3	388.1	1930.
50	1030.	52.8	453.1	2350.
100	1200.	54.9	511.8	2810.
200	1370.	57.7	562.0	3330.
500	1680.	63.2	640.3	4380.

Montana Flood-Frequency and Basin-Characteristic Data

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APPENDIX C

PKFQWIN ANALYSIS

```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.000.000
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       12/10/2013 17:33

                         --- PROCESSING OPTIONS ---

                      Plot option         = None
                      Basin char output   = None
                      Print option        = Yes
                      Debug print         = No
                      Input peaks listing = Long
                      Input peaks format  = WATSTORE peak file

                      Input files used:
                         peaks (ascii)  -
\\TSCLIENT\C\USERS\BEN.FENNELLY\DESKTOP\PKFQWIN\DATA\HYALITE2.TXT
                         specifications - PKFQWPSF.TMP

                      Output file(s):
                         main -
\\TSCLIENT\C\USERS\BEN.FENNELLY\DESKTOP\PKFQWIN\DATA\HYALITE2.PRT

1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.001
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       12/10/2013 17:33

          Station - 06050000  Hyalite C at Hyalite R S nr Bozeman MT


                     I N P U T   D A T A   S U M M A R Y

               Number of peaks in record           =       45
               Peaks not used in analysis          =        0
               Systematic peaks in analysis        =       45
               Historic peaks in analysis          =        0
               Years of historic record            =        0
               Generalized skew                    =    0.073
                    Standard error                 =    0.640
                    Mean Square error              =    0.410
               Skew option                         =   WEIGHTED
               Gage base discharge                 =      0.0
               User supplied high outlier threshold =   --
               User supplied low outlier criterion  =   --
               Plotting position parameter         =     0.00


  *********  NOTICE  --  Preliminary machine computations.        *********
  *********  User responsible for assessment and interpretation.  *********

    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                  0.0
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.           152.8
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.     1159.3
1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.002
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       12/10/2013 17:33
```

HYALITE2

Station - 06050000 Hyalite C at Hyalite R S nr Bozeman MT

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	FLOOD BASE		LOGARITHMIC		
	DISCHARGE	EXCEEDANCE PROBABILITY	MEAN	STANDARD DEVIATION	SKEW
SYSTEMATIC RECORD	0.0	1.0000	2.6242	0.1613	0.194
BULL.17B ESTIMATE	0.0	1.0000	2.6242	0.1613	0.166

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	171.3	173.0	163.5	138.0	200.7
0.9900	185.6	187.1	178.8	151.9	215.4
0.9500	232.6	233.3	228.4	198.1	263.0
0.9000	263.3	263.7	260.2	228.8	294.1
0.8000	307.1	307.0	305.2	272.7	338.9
0.6667	355.7	355.3	354.8	321.0	390.1
0.5000	416.6	415.9	416.6	379.7	456.9
0.4292	445.3	444.5	445.7	406.4	489.6
0.2000	573.5	573.1	577.4	519.8	645.3
0.1000	681.7	682.4	691.0	609.6	786.1
0.0400	823.4	826.3	844.4	722.1	979.9
0.0200	932.6	937.8	966.7	806.0	1135.0
0.0100	1045.0	1053.0	1097.0	890.4	1299.0
0.0050	1161.0	1173.0	1236.0	976.2	1473.0
0.0020	1322.0	1339.0	1437.0	1092.0	1719.0

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 12/10/2013 17:33

Station - 06050000 Hyalite C at Hyalite R S nr Bozeman MT

I N P U T D A T A L I S T I N G

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1951	350.0		1974	799.0	
1952	422.0		1975	729.0	
1953	472.0		1976	420.0	
1954	344.0		1977	248.0	
1955	364.0		1978	263.0	
1956	516.0		1979	349.0	
1957	335.0		1980	224.0	
1958	301.0		1981	948.0	
1959	600.0		1982	413.0	
1960	348.0		1983	500.0	
1961	245.0		1984	419.0	

1962	285.0	1985	194.0
1963	360.0	1986	472.0
1964	394.0	1987	250.0
1965	374.0	1988	604.0
1966	360.0	1989	528.0
1967	540.0	1990	323.0
1968	600.0	1991	624.0
1969	509.0	1992	729.0
1970	866.0	1993	396.0
1971	521.0	1994	338.0
1972	325.0	1995	396.0
1973	689.0		

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.004
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 12/10/2013 17:33

Station - 06050000 Hyalite C at Hyalite R S nr Bozeman MT

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1981	948.0	0.0217	0.0217
1970	866.0	0.0435	0.0435
1974	799.0	0.0652	0.0652
1975	729.0	0.0870	0.0870
1992	729.0	0.1087	0.1087
1973	689.0	0.1304	0.1304
1991	624.0	0.1522	0.1522
1988	604.0	0.1739	0.1739
1959	600.0	0.1957	0.1957
1968	600.0	0.2174	0.2174
1967	540.0	0.2391	0.2391
1989	528.0	0.2609	0.2609
1971	521.0	0.2826	0.2826
1956	516.0	0.3043	0.3043
1969	509.0	0.3261	0.3261
1983	500.0	0.3478	0.3478

1953	472.0	0.3696	0.3696
1986	472.0	0.3913	0.3913
1952	422.0	0.4130	0.4130
1976	420.0	0.4348	0.4348
1984	419.0	0.4565	0.4565
1982	413.0	0.4783	0.4783
1993	396.0	0.5000	0.5000
1995	396.0	0.5217	0.5217
1964	394.0	0.5435	0.5435
1965	374.0	0.5652	0.5652
1955	364.0	0.5870	0.5870
1963	360.0	0.6087	0.6087
1966	360.0	0.6304	0.6304
1951	350.0	0.6522	0.6522
1979	349.0	0.6739	0.6739
1960	348.0	0.6957	0.6957
1954	344.0	0.7174	0.7174
1994	338.0	0.7391	0.7391
1957	335.0	0.7609	0.7609
1972	325.0	0.7826	0.7826
1990	323.0	0.8043	0.8043
1958	301.0	0.8261	0.8261
1962	285.0	0.8478	0.8478
1978	263.0	0.8696	0.8696
1987	250.0	0.8913	0.8913
1977	248.0	0.9130	0.9130
1961	245.0	0.9348	0.9348
1980	224.0	0.9565	0.9565
1985	194.0	0.9783	0.9783

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   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      45
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Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4, or *.)
(2, 4, and * records are ignored.)

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FINISHED PROCESSING STATION: 06050000 USGS Hyalite C at Hyalite R S nr B

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

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  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       12/10/2013 17:26

                         --- PROCESSING OPTIONS ---

                      Plot option         = None
                      Basin char output   = None
                      Print option        = Yes
                      Debug print         = No
                      Input peaks listing = Long
                      Input peaks format  = WATSTORE peak file

                      Input files used:
                         peaks (ascii)  -
\\TSCLIENT\C\USERS\BEN.FENNELLY\DESKTOP\PKFQWIN\DATA\HYALITECREEK.TXT
                         specifications - PKFQWPSF.TMP

                      Output file(s):
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\\TSCLIENT\C\USERS\BEN.FENNELLY\DESKTOP\PKFQWIN\DATA\HYALITE1950.PRT

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  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       12/10/2013 17:26

          Station - 06050000  Hyalite C at Hyalite R S nr Bozeman MT


                     I N P U T   D A T A   S U M M A R Y

               Number of peaks in record           =       19
               Peaks not used in analysis          =        0
               Systematic peaks in analysis        =       19
               Historic peaks in analysis          =        0
               Years of historic record            =        0
               Generalized skew                    =    0.073
                    Standard error                 =    0.640
                    Mean Square error              =    0.410
               Skew option                         =   WEIGHTED
               Gage base discharge                 =      0.0
               User supplied high outlier threshold =   --
               User supplied low outlier criterion  =   --
               Plotting position parameter         =     0.00


  *********  NOTICE  --  Preliminary machine computations.        *********
  *********  User responsible for assessment and interpretation.  *********

    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                   0.0
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.       996.4
    WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.            141.3
1


  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.002
  Ver. 5.2            Annual peak flow frequency analysis      Run Date / Time
  11/01/2007          following Bulletin 17-B Guidelines       12/10/2013 17:26
```

HYALITE1950

Station - 06050000 Hyalite C at Hyalite R S nr Bozeman MT

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	FLOOD BASE		LOGARITHMIC		
	DISCHARGE	EXCEEDANCE PROBABILITY	MEAN	STANDARD DEVIATION	SKEW
SYSTEMATIC RECORD	0.0	1.0000	2.5743	0.1796	0.653
BULL.17B ESTIMATE	0.0	1.0000	2.5743	0.1796	0.398

ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	BULL.17B ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR BULL. 17B ESTIMATES LOWER	UPPER
0.9950	150.9	166.2	136.2	102.2	192.0
0.9900	162.0	175.2	149.1	112.4	203.7
0.9500	199.8	206.9	191.3	148.2	243.1
0.9000	225.5	229.2	219.2	173.3	270.0
0.8000	263.5	263.2	259.4	211.0	310.6
0.6667	307.5	303.9	305.4	254.6	359.6
0.5000	365.1	358.9	365.1	309.7	428.6
0.4292	393.2	386.3	394.4	335.4	464.6
0.2000	526.0	521.3	536.4	446.8	654.3
0.1000	646.9	650.8	673.7	537.8	850.1
0.0400	816.5	841.9	883.6	656.1	1153.0
0.0200	955.7	1006.0	1074.0	747.9	1422.0
0.0100	1106.0	1191.0	1301.0	843.3	1730.0
0.0050	1270.0	1398.0	1576.0	943.3	2083.0
0.0020	1508.0	1714.0	2037.0	1084.0	2630.0

1

Program PeakFq
Ver. 5.2
11/01/2007

U. S. GEOLOGICAL SURVEY
Annual peak flow frequency analysis
following Bulletin 17-B Guidelines

Seq.001.003
Run Date / Time
12/10/2013 17:26

Station - 06050000 Hyalite C at Hyalite R S nr Bozeman MT

I N P U T D A T A L I S T I N G

WATER YEAR	DISCHARGE	CODES	WATER YEAR	DISCHARGE	CODES
1898	956.0		1942	375.0	
1899	760.0		1943	341.0	
1902	500.0		1944	375.0	
1935	441.0		1945	300.0	
1936	205.0		1946	222.0	
1937	330.0		1947	347.0	
1938	502.0		1948	641.0	
1939	286.0		1949	338.0	
1940	360.0		1950	295.0	
1941	206.0				

HYALITE1950

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.004
Ver. 5.2 Annual peak flow frequency analysis Run Date / Time
11/01/2007 following Bulletin 17-B Guidelines 12/10/2013 17:26

Station - 06050000 Hyalite C at Hyalite R S nr Bozeman MT

EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	BULL.17B ESTIMATE
1898	956.0	0.0500	0.0500
1899	760.0	0.1000	0.1000
1948	641.0	0.1500	0.1500
1938	502.0	0.2000	0.2000
1902	500.0	0.2500	0.2500
1935	441.0	0.3000	0.3000
1942	375.0	0.3500	0.3500
1944	375.0	0.4000	0.4000
1940	360.0	0.4500	0.4500
1947	347.0	0.5000	0.5000
1943	341.0	0.5500	0.5500
1949	338.0	0.6000	0.6000
1937	330.0	0.6500	0.6500
1945	300.0	0.7000	0.7000
1950	295.0	0.7500	0.7500
1939	286.0	0.8000	0.8000
1946	222.0	0.8500	0.8500
1941	206.0	0.9000	0.9000
1936	205.0	0.9500	0.9500

1

End PeakFQ analysis.
Stations processed : 1
Number of errors : 0
Stations skipped : 0
Station years : 19

Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4, or *.)
(2, 4, and * records are ignored.)

For the station below, the following records were ignored:

FINISHED PROCESSING STATION: 06050000 USGS Hyalite C at Hyalite R S nr B

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

APPENDIX D

RAINFALL DEPTH CALCULATIONS AND REFERENCES

	2YR	5YR	10YR	25YR	50YR	100YR	500YR
5 min	0.17	0.26	0.33	0.42	0.49	0.57	0.72
15 min	0.31	0.49	0.61	0.77	0.92	1.06	1.35
1 hr	0.45	0.72	0.91	1.13	1.34	1.54	1.94
2 hr	0.52	0.79	0.98	1.22	1.42	1.60	2.04
3 hr	0.59	0.85	1.05	1.30	1.48	1.66	2.08
6 hr	0.75	1.00	1.20	1.50	1.65	1.80	2.25
12 hr	0.94	1.26	1.53	1.88	2.09	2.25	2.81
24 hr	1.20	1.60	1.90	2.30	2.60	2.80	3.37

Values taken from Figures 19-30 of *Precipitation-Frequency Atlas of the Western United States, Volume I - Montana*

Values calculated using Equations 3 & 5 of *Precipitation-Frequency Atlas of the Western United States, Volume I - Montana - East of the divide calcs*

Values interpolated between 2YR and 100YR using Figure 6 of *Precipitation-Frequency Atlas of the Western United States, Volume I - Montana*

Values calculated using Equations 7 & 8 of *Precipitation-Frequency Atlas of the Western United States, Volume I*

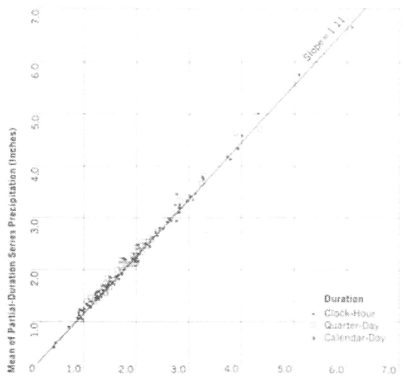
Values interpolated using Figure 17 of *Precipitation-Frequency Atlas of the Western United States, Volume I - Montana*

Values calculated using Table 11 of *Precipitation-Frequency Atlas of the Western United States, Volume I - Montana*

Values determined using ratios provided in *Short Duration Rainfall for the Western United States* (Arkell & Richards) - Front Face and High Plains North Region

Extrapolated using normal-probability relationship

Figure 5. *Relation between annual and partial-duration series.*



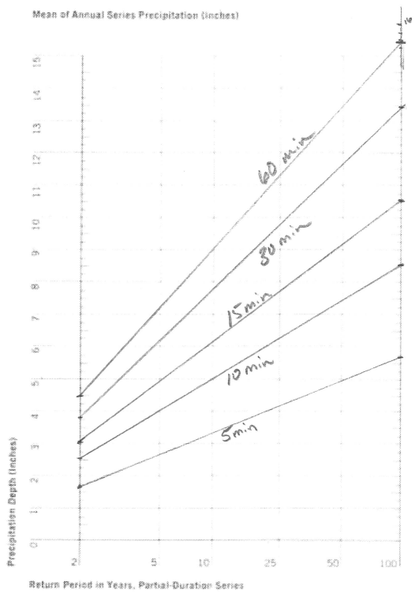
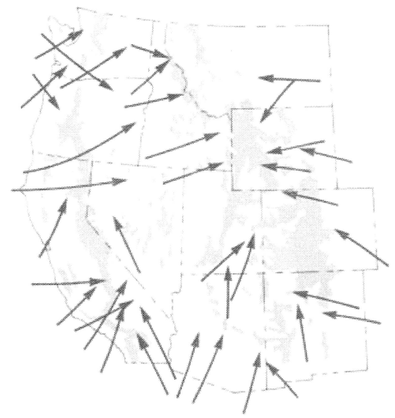


Figure 6. *Precipitation depth versus return period for partial-duration series.*

Figure 7. *Principal paths of moisture inflow in the western United States for storms producing large precipitation amounts. Timed areas are major orographic barriers.*



portant. Next, an examination was made of factors that combined topographic and meteorologic considerations, such as distance and direction to moisture sources. Each factor considered was a measure of some physical reality, and each was understandably related to variation in the precipitation-frequency regime.

Finally, various climatological and meteorological factors that could be indexes of variation of the precipitation-frequency values were considered. The procedure used for developing interpolating equations was a multiple-regression screening technique. This process was done by computer using a least-squares technique. The computer program was capable of accepting a total of 174 independent variables for as many locations as data were available. The number of variables screened for the various relations ranged between 60 and 100. This does not mean that 60 or more completely different factors could be identified. For example, several factors might involve different measures of slope. Moreover, these measures of slope might be over different distances or have different orientations. In each instance, the practice was to permit the computer to select the most critical of the various measures of each factor.

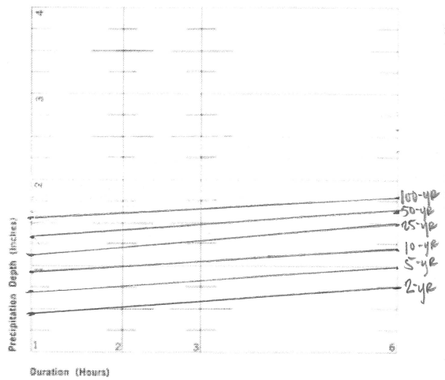
Although the computer program treated each variable as linear during the regression analysis, it was possible through internal computations to use logarithms, powers, roots, reciprocals, or combinations of any or all of the factors. The computer program selected the single variable most highly correlated with the precipitation-frequency value under investigation. The next step was to select the variable that, combined with the variable already selected, would explain the greatest variation in the precipitation-frequency values. The third, fourth, fifth, and further variables were selected in a similar manner. The program continued to select

Region of applicability	Corr. coeff.	No. of stations	Mean of computed stn. values (inches)	Standard error of estimate (inches)
Gila, Williams, and lower Colorado River Basins (1)	0.84	86	1.86	0.21
Little Colorado, San Juan, and Virgin River Basins, except higher elevations of south-facing slopes (2)[1]	0.81	105	1.36	0.20
Higher elevations of south-facing slopes of Little Colorado, San Juan, and Virgin River Basins (2)[1]	0.93	41	1.31	0.13
Rio Grande Basin north of El Paso, Tex. (3)	0.77	110	1.35	0.18
Crest of Continental Divide and Sangre de Cristo Mountains to generalized 7,000-ft contour from southern Wyoming to southern tip of Sangre de Cristo Mountains (4)	0.83	122	1.43	0.22
Upper Colorado and Gunnison River Basins and Green River Basin below confluence of Green and Yampa Rivers (5)	0.79	69	1.12	0.13
Yampa River Basin, Green River Basin above confluence of Green and Yampa Rivers, and Bear River Basin east of Wasatch Mountains (6)	0.83	29	1.03	0.08
Mountains of central Utah (7)	0.85	86	1.35	0.18
Western Utah and Nevada, except Snake and Virgin River Basins and spillover zone east of Sierra Nevada Crest (8)[1]	0.71	79	1.03	0.13
Western Utah and Nevada, except Snake and Virgin River Basins and spillover zone east of Sierra Nevada crest (8)[1]	0.71	55	1.04	0.15
Big Horn River Basin above Saint Xavier and minor portions of North Platte, Powder, Tongue, and Yellowstone River Basins (9)	0.78	55	1.25	0.21
Upper Missouri River Basin above Holter Dam, Mont.; Snake River Basin above Alpine, Wyo.; and upper Yellowstone River Basin above Springdale, Mont. (10)	0.76	57	1.19	0.16
From generalized 4,000-ft contour on east to crests of Crazy and Little Belt Mountains and Lewis Range on west (11)	0.80	52	1.67	0.26
West of Continental Divide, but east of Bitterroot Range and Cabinet and Selkirk Mountains (12)	0.85	44	1.36	0.12
Mountainous region of eastern Washington and Oregon and of Idaho west of Bitterroot Range crest and Continental Divide, and north of southern boundary of Snake River Basin—excluding Snake River Valley below a generalized 5,000-ft contour (13)	0.78	147	1.44	0.24
Orographic region east of crest of Cascade Range and west of Snake River Basin (14)	0.90	115	1.75	0.35
Western slopes of Coast Ranges, Olympic Mountains, and Cascade Range (15)	0.87	125	3.69	0.48
Eel River Basin; southern portion of Klamath River Basin, and Cottonwood, Elder, Thomas, and Gladstone Creeks (16)	0.91	39	4.19	0.50
Russian River, Cache and Putah Creeks, and coastal drainages west of Russian River (17)	0.84	63	5.31	0.78
Santa Cruz Mountains and La Panza, Santa Lucia, and Coast Ranges (18)	0.95	55	4.32	0.45
Diablo, Gabilan, and Temblor Ranges (19)	0.82	58	2.21	0.35
San Rafael, San Bernardino, Santa Monica, and San Gabriel Mountains (20)	0.88	149	3.98	0.59
Santa Ana, Santa Rosa, Coyote, and other extreme southern coastal mountains (21)	0.88	34	2.44	0.33
Northern Sierra Nevada north of Mokelumne River Basin (22)	0.92	84	4.56	0.53
Southern Sierra Nevada south of Consumnes River Basin (23)	0.88	61	3.43	0.53
Southeastern desert region of California (24)	0.89	41	1.07	0.16
Spillover zone east of Sierra Nevada crest (25)	0.94	41	2.05	0.27
Spillover zone east of crest of coastal mountains of southern California (26)	0.97	10	2.08	0.15

[1] Numbers in parentheses refer to geographic regions shown in figure 8.
[2] Two different equations were used in region 2. See text for explanation.
[3] Two different equations were used in region 8. See text for explanation.

Table 3. *Statistical parameters for relations used for interstation interpolation of 2-yr 24-hr precipitation values*

Figure 16. *Precipitation depth-duration diagram (1 to 6 hrs).*



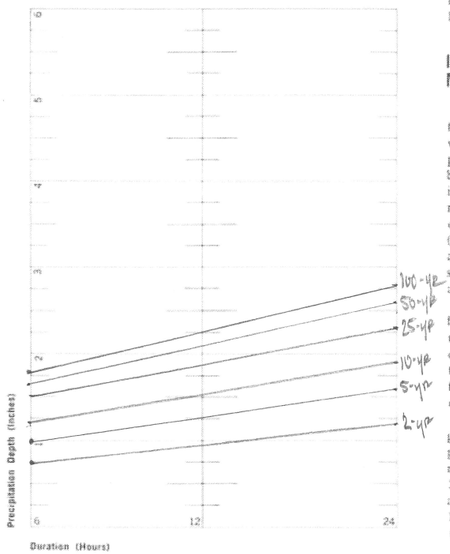


Figure 17. *Precipitation depth-duration diagram (6 to 24 hrs).*

Estimates for 2- and 3-hr (120- and 180-min) precipitation-frequency values. To obtain estimates of precipitation-frequency values for 2 or 3 hrs, plot the 6-hr value from the Atlas maps and the 1-hr value on the nomogram of figure 16. Then draw a straight line connecting the 1- and 6-hr values, and read the 2- and 3-hr values from the nomogram. This nomogram is independent of return period. It was developed using data from the same regions used to develop the 1-hr equations. The slight differences found in data from east and west of the Continental Divide were smaller than the sampling error inherent in the data, so one nomogram will serve for all sections of Montana. The mathematical solution from the data used to develop figure 16 gives the following equations for estimating the 2- and 3-hr values:

$$2\text{ hr} = 0.250\ (6\text{ hr}) + 0.750\ (1\text{ hr}), \qquad (7)$$

$$3\text{ hr} = 0.467\ (6\text{ hr}) + 0.533\ (1\text{ hr}). \qquad (8)$$

Estimates for 12-hr (720-min) precipitation. To obtain estimates for the 12-hr duration, plot values from the 6- and 24-hr maps on the nomogram of figure 17. The 12-hr estimates can then be read at the intersection of the line connecting these points with the 12-hr duration line of the nomogram.

Estimates for less than 1 hr. To obtain estimates for durations of less than 1 hr, the values in table 11 are applied to the 1-hr value for the return period of interest.

Illustration of Use of Precipitation-Frequency Maps, Diagrams, and Equations.

To illustrate the use of these maps, values were read from figures 19 to 30 for the point at 47°00′ N. and 110°00′ W. These values are shown in boldface type in table 12. Because not all points are as easy to locate as latitude-longitude intersections, and because there may be some slight registration differences in printing, precise interpolation between isolines is difficult; the values read from the maps should be plotted on the return-period diagram of figure 6. This has been done for the 24-hr values in table 12 (fig. 18a). On this nomogram the 25-yr value appears somewhat above the line, so the value read from the maps is corrected (as shown by the strikeout in table 12); such corrected values are adopted in preference to the original readings.

The 2- and 100-yr 1-hr values for the point were computed from equations (3) and (5), since the point is east of the Continental Divide. The 2-yr 1-hr value is estimated at 0.50 in. from equation (3); using equation (5) (and an elevation of 4,400 ft), the 100-yr 1-hr value is 1.53 in. By plotting these 1-hr values on figure 6 and connecting them with a straight line, one can obtain estimates for return periods of 5, 10, 25, and 50 yrs.

The 2- and 3-hr values can be estimated by using the nomogram of figure 16. The 1- and 6-hr values for the desired return period are obtained as above. Plot these points on the figure 16 nomogram and connect them with a straight line; the estimates for 2 or 3 hrs can be read at the intersections of the connecting line and the 2- and 3-hr vertical lines. An example is shown in figure 18b for the 100-yr return period. The values of the 100-yr 2-hr (1.70 in.) and 100-yr 3-hr (1.85 in.) are in italics on table 12.

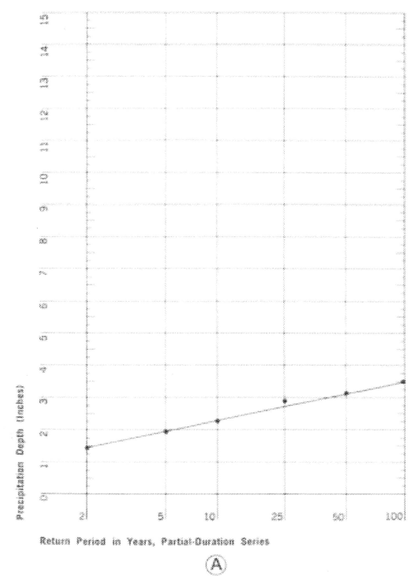
Table 11. *Adjustment factors to obtain n-minute estimates from 1-hr values*

Duration (min)	5	10	15	30
Ratio to 1-hr	0.29	0.45	0.57	0.79

(Adopted from *U.S. Weather Bureau Technical Paper* No. 40, 1961.)

Table 12. *Precipitation data for depth-frequency atlas computation point 47°00′ N., 110°00′ W.*

	1-hr	2-hr	3-hr	6-hr	24-hr
2-yr	0.50			**0.88**	**1.47**
5-yr				**1.19**	**1.96**
10-yr				**1.42**	**2.30**
25-yr				**1.78**	**2.77** ~~**2.84**~~
50-yr				**1.98**	**3.18**
100-yr	*1.53*	*1.70*	*1.85*	**2.18**	**3.50**



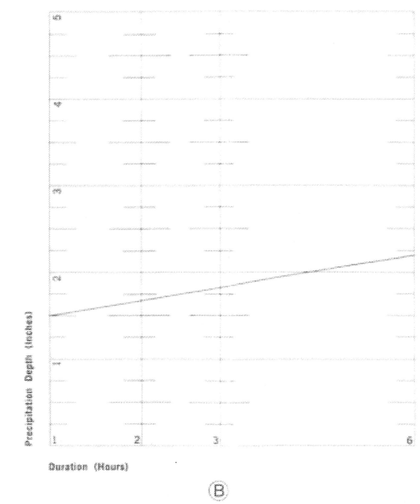


Figure 18. *Illustration of use of precipitation-frequency diagrams using values from precipitation-frequency maps and relations at 47°00′ N., 110°00′ W.*

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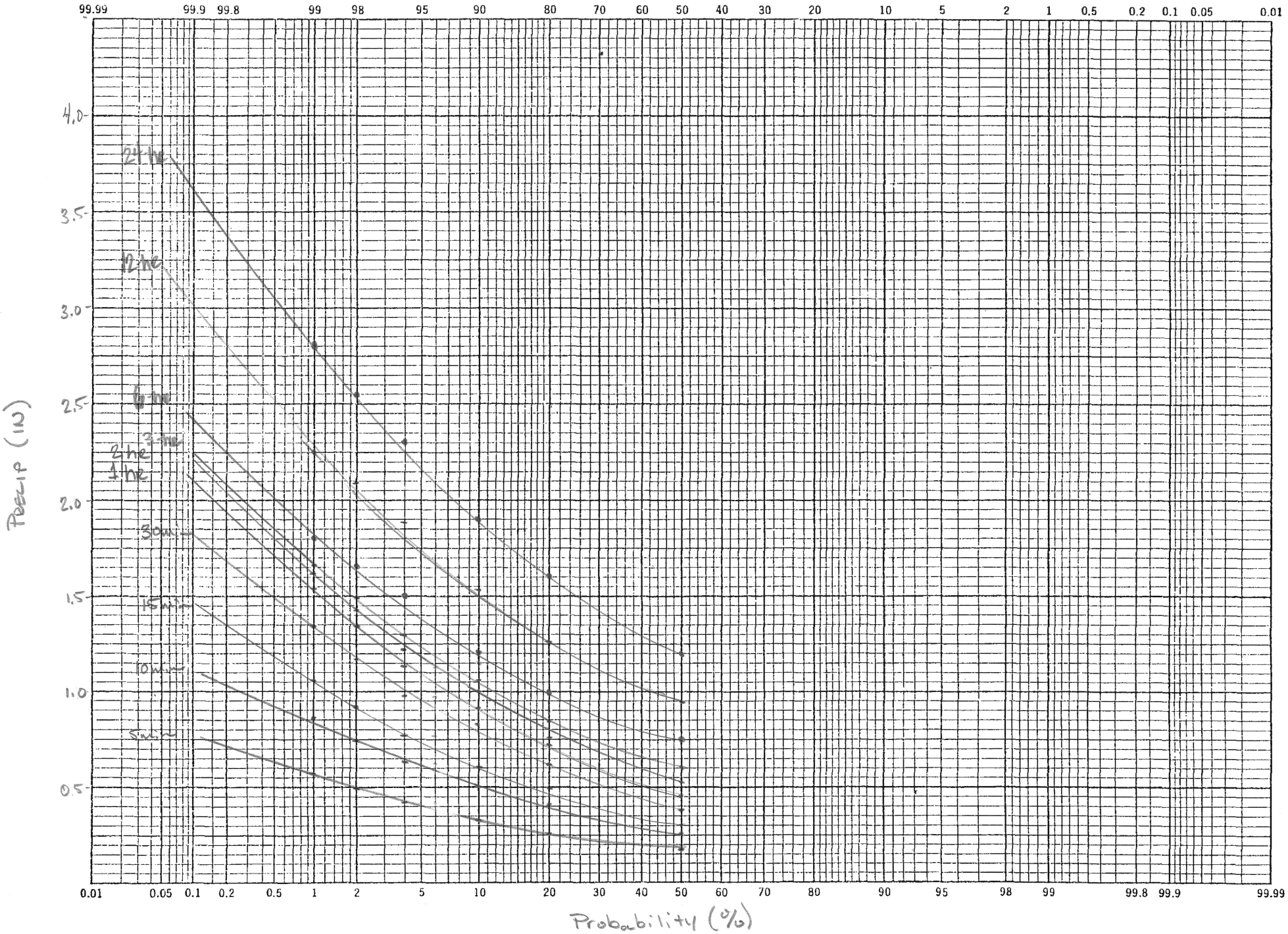

APPENDIX E

CURVE NUMBER LOOK-UP TABLE

Land Use Category	Hydrologic Soil Group				Description	Assumption	Reference	Source
	A	B	C	D				
Shrub/Scrub	30	48	65	73	Shrub/Scrub	Good hydrologic conditions	Engineering Hydrology - Principles and Practices (Ponce)	NLCD
Deciduous Forest	30	55	70	77	Deciduous Forest	Good hydrologic conditions	Engineering Hydrology - Principles and Practices (Ponce)	
Evergreen Forest	30	55	70	77	Evergreen Forest	Good hydrologic conditions	Engineering Hydrology - Principles and Practices (Ponce)	
Mixed Forest	30	55	70	77	Mixed Forest	Good hydrologic conditions	Engineering Hydrology - Principles and Practices (Ponce)	
Developed, Open Space	39	61	74	80	Developed, Open Space	Lawns, parks, cemeteries with vegetation established	Engineering Hydrology - Principles and Practices (Ponce)	
Hay/Pasture	39	61	74	80	Hay/Pasture	Pasture, grassland or range for grazing - Good hydrologic conditions	Engineering Hydrology - Principles and Practices (Ponce)	
Pasture/Hay	39	61	74	80	Hay/Pasture	Pasture, grassland or range for grazing - Good hydrologic conditions	Engineering Hydrology - Principles and Practices (Ponce)	
Herbaceuous		62	74	85	Herbaceous	Good hydrologic conditions	Engineering Hydrology - Principles and Practices (Ponce)	
Grassland/Herbaceous		62	74	85	Herbaceous	Good hydrologic conditions	Engineering Hydrology - Principles and Practices (Ponce)	
Developed, Low Intensity	60	70	80	85	Developed, Low Intensity	1/2 acre lots - vegetation established	Engineering Hydrology - Principles and Practices (Ponce)	
Developed, Medium Intensity	61	75	83	87	Developed, Medium Intensity	1/4 acre lots - vegetation established	Engineering Hydrology - Principles and Practices (Ponce)	
Developed, High Intensity	77	85	90	92	Developed, High Intensity	Town houses	Engineering Hydrology - Principles and Practices (Ponce)	
Open Water	98	98	98	98	Open Water			
Cultivated Crops	58	72	81	85	Cultivated Crops	Close-seeded or broadcast legumes or rotation meadow straight row	Engineering Hydrology - Principles and Practices (Ponce)	
Emergent Herbaceous Wetlands	78	78	78	78	Emergent Herbaceous Wetlands		Michigan DEQ	
Woody Wetlands	78	78	78	78	Woody Wetlands		Michigan DEQ	
GOLF	39	61	74	80	Golf Course - A tract of land laid out for playing golf with at least nine holes; and improved with tees, greens, fairways and hazards; and which may include a clubhouse and/or shelter.	Park/Open Space	Engineering Hydrology - Principles and Practices (Ponce)	City of Bozeman
AG	63	75	83	87	Agricultural Land, usually 20 acres or greater, without dwellings	Small grain, straight row	Engineering Hydrology - Principles and Practices (Ponce)	
MFR	77	85	90	92	Multi-Household Residential - A building, or portion thereof, used for occupancy by four or more households living independently of each other, with the units completely separated by a common wall, floor and/or ceiling; apartments, condos.	Multi-family residential - Town houses	Engineering Hydrology - Principles and Practices (Ponce)	
POS	39	61	74	80	Park or Open Space - Parks, trails, recreational areas and other places that are capable of being used by the public for recreation, relaxation and social purposes. May include private land serving a property owners association for similar purposes	Park/Open Space	Engineering Hydrology - Principles and Practices (Ponce)	
ROW	98	98	98	98	Rights-of-Way - A public way established or dedicated for public purposes by duly recorded plat, deed, grant, easement, governmental authority or by operation of law; roads; railroads.	Right-of-way/Paved roads: curbs and storm sewers	Engineering Hydrology - Principles and Practices (Ponce)	
RR	59	74	82	86	Rural Residential - Detached single-household residential property located outside of the City limits that does not have pasture.	Farmsteads - buildings, lanes, driveways, and surrounding lots	Engineering Hydrology - Principles and Practices (Ponce)	
SFR	61	75	83	87	Single-Household Residential - A building used for residential occupancy by one household, including multiple residences that share a common wall, as long as only one dwelling unit lies upon a single lot; townhomes. Also may include an accessory dwelling unit.	Single family residential - 1/4 acre lots - vegetation established	Engineering Hydrology - Principles and Practices (Ponce)	
AP	77	85	90	92	Administrative Professional - An establishment in which overall management functions occur and/or in which a recognized profession is maintained for the conduct of that profession.	Apartments - multi-family residential and town houses	Engineering Hydrology - Principles and Practices (Ponce)	
CA	89	92	94	95	Commercial Auto sales, rental, parts, storage, gas, service - Establishments primarily engaged in automotive related sale/services, fuels, repair, sales, washing, rental and leasing.	Commercial	Engineering Hydrology - Principles and Practices (Ponce)	
CHURCH	89	92	94	95	A building where persons regularly assemble for religious worship and which, together with its accessory buildings and uses, is maintained and controlled by a religious body organized to sustain public worship.	Resemble commercial	Engineering Hydrology - Principles and Practices (Ponce)	
CR	89	92	94	95	Commercial Retail sales, services, Banks - Uses involving the sale of goods or services carried out for profit.	Commercial	Engineering Hydrology - Principles and Practices (Ponce)	
DTR	77	85	90	92	Duplex/Triplex Residential - A building, or a portion thereof, used for occupancy by two or three households living independently of each other, with the units completely separated by a common wall, floor and/or ceiling and reside on one lot; including apartments and condos.	Dual residential - multi-family residential and town houses	Engineering Hydrology - Principles and Practices (Ponce)	
HM	89	92	94	95	Hotel/Motel - A building or group of buildings, in which lodging is provided and offered to transient guests for compensation (not to include a boarding house, lodging house or rooming house)>	Heavy Manufacturing - Commercial	Engineering Hydrology - Principles and Practices (Ponce)	
LM	89	92	94	95	Light Manufacturing - Fabrication of and/or assembly of goods from previously prepared materials, to include storage, and mini-warehousing.	Light Manufacturing - Commercial	Engineering Hydrology - Principles and Practices (Ponce)	
MHMP	77	85	90	92	Manufactured Homes/Motor Parks	Multi-family residential	Engineering Hydrology - Principles and Practices (Ponce)	
MIXED	65	77	84	88	More than one principal use occurring on one lot.	For Figgins Creek - Largely commercial with approx. 40% deciduous forest		
PFP					Public Facility - A building, structure, facility or complex, used by or providing services to the general public and constructed by either the federal, state, county or municipal government agency. Also includes utilities serving the general public such as electrical service.			
RB	89	92	94	95	Restaurant/Bar - A restaurant, coffee shop, cafeteria, grill, short order café, luncheonette, sandwich stand, drugstore, soda fountain, serving food; or an establishment where alcoholic beverages are served on premises.	Commercial		
SEF	68	79	86	89	School/Educational Facility - Any building or part thereof which is constructed or used for public or private education or instruction; when not conducted as a commercial enterprise for the profit of individual owners or stockholders.	School and education facilities - open space poor condition (grass covers less than 50%)	Engineering Hydrology - Principles and Practices (Ponce)	
UDV	63	75	83	87	Undeveloped - Land that is no longer, or has never been, in agricultural use and is not ready to be occupied by buildings (needs to be subdivided; needs infrastructure)	Figgins Creek - Based upon Bozeman City aerial, UDV areas of Figgins Creek watershed appear to be used for agricultural purposes - small grain, straight row		
VACANT	77	86	91	94	Vacant - Land that is currently developed and ready to be occupied by buildings but is unoccupied; no buildings or buildings requiring significant improvement in order to be used.	Graded areas - pervious areas only with no vegetation	Engineering Hydrology - Principles and Practices (Ponce)	

APPENDIX F

CURVE NUMBER CALCULATIONS

BASIN	LAND USE CATEGORY	SOIL MAP UNIT #	SUBREGION CN	SUBREGION AREA (mi^2)	SUBBASIN AREA (mi^2)	PERCENT OF SUBBASIN	CUMULATIVE PERCENT	AREA-WEIGHTED CN	CUMULATIVE CN	COMPOSITE CN
FC01	Developed, Open Space	C	74.0	0.03	0.09	34.02%	34.0%	25.2	25.2	
FC01	Developed, Open Space	B	61.0	0.00	0.09	0.45%	34.5%	0.3	25.5	
FC01	Developed, Low Intensity	C	80.0	0.00	0.09	0.67%	35.1%	0.5	26.0	
FC01	CR	C	94.0	0.00	0.09	0.54%	35.7%	0.5	26.5	
FC01	CR	B	92.0	0.00	0.09	1.09%	36.8%	1.0	27.5	
FC01	DTR	C	90.0	0.02	0.09	20.51%	57.3%	18.5	46.0	
FC01	DTR	B	85.0	0.00	0.09	3.08%	60.4%	2.6	48.6	
FC01	GOLF	C	74.0	0.00	0.09	4.19%	64.6%	3.1	51.7	
FC01	MFR	C	90.0	0.00	0.09	5.17%	69.7%	4.7	56.3	
FC01	MFR	B	85.0	0.00	0.09	4.66%	74.4%	4.0	60.3	
FC01	POS	C	74.0	0.00	0.09	3.87%	78.3%	2.9	63.2	
FC01	POS	B	61.0	0.00	0.09	1.45%	79.7%	0.9	64.0	
FC01	ROW	C	98.0	0.00	0.09	4.52%	84.2%	4.4	68.5	
FC01	ROW	B	98.0	0.00	0.09	2.05%	86.3%	2.0	70.5	
FC01	SFR	C	83.0	0.01	0.09	9.65%	95.9%	8.0	78.5	
FC01	SFR	B	75.0	0.00	0.09	1.52%	97.4%	1.1	79.6	
FC01	MFR	C	90.0	0.00	0.09	2.56%	100.0%	2.3	81.9	
FC01	ROW	C	98.0	0.00	0.09	2.56%	102.6%	2.5	84.4	**84.4**
Mouth	Developed, Open Space	C	74.0	0.68	3.96	17.26%	17.3%	12.8	12.8	
Mouth	Developed, Open Space	B	61.0	0.03	3.96	0.82%	18.1%	0.5	13.3	
Mouth	Developed, Open Space	D	80.0	0.03	3.96	0.65%	18.7%	0.5	13.8	
Mouth	Developed, Low Intensity	C	80.0	0.09	3.96	2.28%	21.0%	1.8	15.6	
Mouth	Developed, Low Intensity	B	70.0	0.00	3.96	0.05%	21.1%	0.0	15.7	
Mouth	Developed, Low Intensity	D	85.0	0.00	3.96	0.03%	21.1%	0.0	15.7	
Mouth	Developed, Medium Intensity	C	83.0	0.00	3.96	0.03%	21.1%	0.0	15.7	
Mouth	Deciduous Forest	C	70.0	0.00	3.96	0.10%	21.2%	0.1	15.8	
Mouth	Deciduous Forest	B	55.0	0.02	3.96	0.46%	21.7%	0.3	16.0	
Mouth	Evergreen Forest	C	70.0	0.01	3.96	0.15%	21.8%	0.1	16.1	
Mouth	Evergreen Forest	B	55.0	0.25	3.96	6.30%	28.1%	3.5	19.6	
Mouth	Evergreen Forest	D	77.0	0.02	3.96	0.55%	28.7%	0.4	20.0	
Mouth	Mixed Forest	C	70.0	0.00	3.96	0.02%	28.7%	0.0	20.0	
Mouth	Mixed Forest	B	55.0	0.00	3.96	0.00%	28.7%	0.0	20.0	
Mouth	Shrub/Scrub	C	65.0	0.14	3.96	3.53%	32.2%	2.3	22.3	
Mouth	Shrub/Scrub	B	48.0	0.01	3.96	0.14%	32.4%	0.1	22.4	
Mouth	Shrub/Scrub	D	73.0	0.00	3.96	0.00%	32.4%	0.0	22.4	
Mouth	Cultivated Crops	C	81.0	0.50	3.96	12.76%	45.1%	10.3	32.7	
Mouth	Cultivated Crops	B	72.0	0.11	3.96	2.79%	47.9%	2.0	34.7	
Mouth	Woody Wetlands	D	78.0	0.00	3.96	0.01%	47.9%	0.0	34.7	
Mouth	AP	C	90.0	0.02	3.96	0.55%	48.5%	0.5	35.2	
Mouth	AP	D	92.0	0.00	3.96	0.07%	48.6%	0.1	35.3	
Mouth	CA	C	94.0	0.00	3.96	0.01%	48.6%	0.0	35.3	
Mouth	CHURCH	C	94.0	0.01	3.96	0.26%	48.8%	0.2	35.6	
Mouth	CR	C	94.0	0.00	3.96	0.06%	48.9%	0.1	35.6	
Mouth	CR	B	92.0	0.00	3.96	0.04%	48.9%	0.0	35.7	
Mouth	DTR	C	90.0	0.01	3.96	0.17%	49.1%	0.2	35.8	
Mouth	DTR	B	85.0	0.01	3.96	0.26%	49.4%	0.2	36.0	
Mouth	DTR	D	92.0	0.00	3.96	0.02%	49.4%	0.0	36.1	
Mouth	GOLF	C	74.0	0.00	3.96	0.00%	49.4%	0.0	36.1	
Mouth	Hay/Pasture	C	74.0	0.56	3.96	14.05%	63.4%	10.4	46.4	
Mouth	Hay/Pasture	B	61.0	0.17	3.96	4.42%	67.8%	2.7	49.1	
Mouth	Hay/Pasture	D	80.0	0.01	3.96	0.24%	68.1%	0.2	49.3	
Mouth	Herbaceuous	C	74.0	0.04	3.96	1.06%	69.1%	0.8	50.1	
Mouth	Herbaceuous	B	62.0	0.00	3.96	0.02%	69.2%	0.0	50.1	
Mouth	LM	C	94.0	0.01	3.96	0.28%	69.4%	0.3	50.4	
Mouth	MFR	C	90.0	0.04	3.96	0.93%	70.4%	0.8	51.2	
Mouth	MFR	B	85.0	0.01	3.96	0.30%	70.7%	0.3	51.5	
Mouth	MFR	D	92.0	0.00	3.96	0.12%	70.8%	0.1	51.6	
Mouth	MIXED	C	84.0	0.01	3.96	0.20%	71.0%	0.2	51.8	
Mouth	MIXED	D	88.0	0.00	3.96	0.06%	71.0%	0.1	51.8	
Mouth	POS	C	74.0	0.13	3.96	3.23%	74.3%	2.4	54.2	
Mouth	POS	B	61.0	0.02	3.96	0.63%	74.9%	0.4	54.6	
Mouth	POS	D	80.0	0.03	3.96	0.67%	75.6%	0.5	55.1	
Mouth	RB	C	94.0	0.00	3.96	0.00%	75.6%	0.0	55.1	
Mouth	RB	D	95.0	0.00	3.96	0.01%	75.6%	0.0	55.1	
Mouth	ROW	C	98.0	0.20	3.96	5.08%	80.7%	5.0	60.1	
Mouth	ROW	B	98.0	0.04	3.96	1.03%	81.7%	1.0	61.1	
Mouth	ROW	D	98.0	0.00	3.96	0.12%	81.8%	0.1	61.2	
Mouth	SEF	C	86.0	0.11	3.96	2.66%	84.5%	2.3	63.5	
Mouth	SEF	D	89.0	0.00	3.96	0.02%	84.5%	0.0	63.5	
Mouth	SFR	C	83.0	0.40	3.96	10.23%	94.7%	8.5	72.0	
Mouth	SFR	B	75.0	0.05	3.96	1.38%	96.1%	1.0	73.1	
Mouth	SFR	D	87.0	0.01	3.96	0.37%	96.5%	0.3	73.4	
Mouth	UDV	C	83.0	0.10	3.96	2.41%	98.9%	2.0	75.4	
Mouth	UDV	D	87.0	0.01	3.96	0.18%	99.1%	0.2	75.6	
Mouth	VACANT	C	91.0	0.03	3.96	0.65%	99.7%	0.6	76.1	
Mouth	VACANT	B	86.0	0.01	3.96	0.18%	99.9%	0.2	76.3	
Mouth	VACANT	D	94.0	0.00	3.96	0.09%	100.0%	0.1	76.4	
Mouth	Evergreen Forest	B	55.0	0.00	3.96	0.00%	100.0%	0.0	76.4	
Mouth	Evergreen Forest	D	77.0	0.00	3.96	0.00%	100.0%	0.0	76.4	**76.4**
N01	Developed, Open Space	C	74.0	0.45	4.31	10.51%	10.5%	7.8	7.8	
N01	Developed, Open Space	B	61.0	0.07	4.31	1.65%	12.2%	1.0	8.8	
N01	Developed, Open Space	D	80.0	0.00	4.31	0.03%	12.2%	0.0	8.8	
N01	Developed, Low Intensity	C	80.0	0.04	4.31	0.95%	13.1%	0.8	9.6	
N01	Developed, Low Intensity	B	70.0	0.01	4.31	0.20%	13.3%	0.1	9.7	
N01	Developed, Low Intensity	D	85.0	0.00	4.31	0.00%	13.3%	0.0	9.7	
N01	Deciduous Forest	C	70.0	0.00	4.31	0.03%	13.4%	0.0	9.7	
N01	Deciduous Forest	A	30.0	0.06	4.31	1.49%	14.9%	0.4	10.2	
N01	Deciduous Forest	B	55.0	0.11	4.31	2.56%	17.4%	1.4	11.6	
N01	Evergreen Forest	C	70.0	0.02	4.31	0.55%	18.0%	0.4	12.0	
N01	Evergreen Forest	A	30.0	0.36	4.31	8.38%	26.4%	2.5	14.5	
N01	Evergreen Forest	B	55.0	1.10	4.31	25.55%	51.9%	14.1	28.5	
N01	Evergreen Forest	D	77.0	0.24	4.31	5.51%	57.4%	4.2	32.8	
N01	Mixed Forest	C	70.0	0.00	4.31	0.06%	57.5%	0.0	32.8	
N01	Shrub/Scrub	C	65.0	0.12	4.31	2.74%	60.2%	1.8	34.6	
N01	Shrub/Scrub	A	30.0	0.03	4.31	0.77%	61.0%	0.2	34.8	
N01	Shrub/Scrub	B	48.0	0.06	4.31	1.45%	62.4%	0.7	35.5	
N01	Shrub/Scrub	D	73.0	0.03	4.31	0.68%	63.1%	0.5	36.0	

BASIN	LAND USE CATEGORY	SOIL MAP UNIT #	SUBREGION CN	SUBREGION AREA (mi^2)	SUBBASIN AREA (mi^2)	PERCENT OF SUBBASIN	CUMULATIVE PERCENT	AREA-WEIGHTED CN	CUMULATIVE CN	COMPOSITE CN
N01	Cultivated Crops	C	81.0	0.48	4.31	11.10%	74.2%	9.0	45.0	
N01	Cultivated Crops	B	72.0	0.08	4.31	1.78%	76.0%	1.3	46.3	
N01	Cultivated Crops	D	85.0	0.05	4.31	1.21%	77.2%	1.0	47.3	
N01	Woody Wetlands	C	78.0	0.01	4.31	0.34%	77.5%	0.3	47.6	
N01	Woody Wetlands	B	78.0	0.00	4.31	0.00%	77.5%	0.0	47.6	
N01	Woody Wetlands	D	78.0	0.01	4.31	0.32%	77.9%	0.2	47.8	
N01	DTR	C	90.0	0.02	4.31	0.44%	78.3%	0.4	48.2	
N01	DTR	B	85.0	0.00	4.31	0.03%	78.3%	0.0	48.3	
N01	Hay/Pasture	C	74.0	0.64	4.31	14.79%	93.1%	10.9	59.2	
N01	Hay/Pasture	B	61.0	0.08	4.31	1.90%	95.0%	1.2	60.4	
N01	Hay/Pasture	D	80.0	0.07	4.31	1.55%	96.6%	1.2	61.6	
N01	Herbaceuous	C	74.0	0.02	4.31	0.46%	97.0%	0.3	61.9	
N01	Herbaceuous	B	62.0	0.01	4.31	0.13%	97.2%	0.1	62.0	
N01	Herbaceuous	D	85.0	0.00	4.31	0.02%	97.2%	0.0	62.0	
N01	MFR	C	90.0	0.00	4.31	0.01%	97.2%	0.0	62.0	
N01	MFR	B	85.0	0.00	4.31	0.01%	97.2%	0.0	62.1	
N01	POS	C	74.0	0.03	4.31	0.78%	98.0%	0.6	62.6	
N01	POS	B	61.0	0.02	4.31	0.57%	98.5%	0.4	63.0	
N01	POS	D	80.0	0.01	4.31	0.13%	98.7%	0.1	63.1	
N01	ROW	C	98.0	0.01	4.31	0.16%	98.8%	0.2	63.2	
N01	ROW	B	98.0	0.01	4.31	0.23%	99.1%	0.2	63.5	
N01	ROW	D	98.0	0.00	4.31	0.00%	99.1%	0.0	63.5	
N01	SFR	C	83.0	0.02	4.31	0.38%	99.4%	0.3	63.8	
N01	SFR	B	75.0	0.02	4.31	0.44%	99.9%	0.3	64.1	
N01	VACANT	C	91.0	0.00	4.31	0.02%	99.9%	0.0	64.1	
N01	VACANT	B	86.0	0.00	4.31	0.04%	100.0%	0.0	64.2	
N01	Emergent Herbaceous Wetlands	C	78.0	0.00	4.31	0.02%	100.0%	0.0	64.2	
N01	Emergent Herbaceous Wetlands	D	78.0	0.00	4.31	0.00%	100.0%	0.0	64.2	
N01	Evergreen Forest	A	30.0	0.00	4.31	0.00%	100.0%	0.0	64.2	
N01	Evergreen Forest	B	55.0	0.00	4.31	0.00%	100.0%	0.0	64.2	
N01	Evergreen Forest	A	30.0	0.00	4.31	0.00%	100.0%	0.0	64.2	
N01	Evergreen Forest	D	77.0	0.00	4.31	0.00%	100.0%	0.0	64.2	
N01	Evergreen Forest	B	55.0	0.00	4.31	0.00%	100.0%	0.0	64.2	
N01	Evergreen Forest	D	77.0	0.00	4.31	0.00%	100.0%	0.0	64.2	**64.2**
W01	Developed, Open Space	C	74.0	0.00	0.13	0.23%	0.2%	0.2	0.2	
W01	Developed, Open Space	D	80.0	0.00	0.13	0.86%	1.1%	0.7	0.9	
W01	Developed, Low Intensity	D	85.0	0.00	0.13	0.08%	1.2%	0.1	0.9	
W01	AP	C	90.0	0.00	0.13	0.34%	1.5%	0.3	1.2	
W01	AP	D	92.0	0.00	0.13	0.31%	1.8%	0.3	1.5	
W01	CA	C	94.0	0.00	0.13	1.22%	3.0%	1.1	2.7	
W01	CR	C	94.0	0.00	0.13	0.85%	3.9%	0.8	3.5	
W01	CR	D	95.0	0.00	0.13	0.63%	4.5%	0.6	4.1	
W01	LM	C	94.0	0.02	0.13	19.05%	23.6%	17.9	22.0	
W01	LM	D	95.0	0.01	0.13	7.30%	30.9%	6.9	28.9	
W01	MIXED	C	84.0	0.01	0.13	5.89%	36.8%	4.9	33.8	
W01	MIXED	D	88.0	0.02	0.13	15.32%	52.1%	13.5	47.3	
W01	RB	C	94.0	0.00	0.13	0.49%	52.6%	0.5	47.8	
W01	ROW	C	98.0	0.01	0.13	8.27%	60.8%	8.1	55.9	
W01	ROW	D	98.0	0.00	0.13	2.07%	62.9%	2.0	57.9	
W01	SEF	D	89.0	0.00	0.13	0.03%	62.9%	0.0	57.9	
W01	SFR	C	83.0	0.00	0.13	0.50%	63.4%	0.4	58.4	
W01	SFR	D	87.0	0.00	0.13	0.15%	63.6%	0.1	58.5	
W01	UDV	C	83.0	0.01	0.13	11.54%	75.1%	9.6	68.1	
W01	UDV	D	87.0	0.03	0.13	24.14%	99.3%	21.0	89.1	
W01	VACANT	C	91.0	0.00	0.13	0.74%	100.0%	0.7	89.7	**89.7**
W010	Developed, Open Space	C	74.0	0.02	0.17	12.90%	12.9%	9.5	9.5	
W010	Developed, Open Space	B	61.0	0.04	0.17	22.83%	35.7%	13.9	23.5	
W010	Developed, Open Space	D	80.0	0.00	0.17	0.65%	36.4%	0.5	24.0	
W010	Developed, Low Intensity	C	80.0	0.01	0.17	4.27%	40.7%	3.4	27.4	
W010	Developed, Low Intensity	B	70.0	0.00	0.17	2.81%	43.5%	2.0	29.4	
W010	Developed, Low Intensity	D	85.0	0.00	0.17	0.00%	43.5%	0.0	29.4	
W010	Evergreen Forest	D	77.0	0.00	0.17	0.01%	43.5%	0.0	29.4	
W010	Mixed Forest	C	70.0	0.00	0.17	0.44%	43.9%	0.3	29.7	
W010	Mixed Forest	B	55.0	0.00	0.17	0.57%	44.5%	0.3	30.0	
W010	Shrub/Scrub	C	65.0	0.01	0.17	6.73%	51.2%	4.4	34.4	
W010	Shrub/Scrub	B	48.0	0.03	0.17	20.45%	71.7%	9.8	44.2	
W010	Woody Wetlands	C	78.0	0.00	0.17	1.06%	72.7%	0.8	45.0	
W010	Woody Wetlands	B	78.0	0.00	0.17	0.01%	72.7%	0.0	45.0	
W010	Woody Wetlands	D	78.0	0.01	0.17	4.51%	77.2%	3.5	48.5	
W010	Hay/Pasture	C	74.0	0.02	0.17	13.68%	90.9%	10.1	58.7	
W010	Hay/Pasture	B	61.0	0.00	0.17	1.76%	92.7%	1.1	59.7	
W010	Hay/Pasture	D	80.0	0.01	0.17	4.80%	97.5%	3.8	63.6	
W010	Herbaceuous	C	74.0	0.00	0.17	0.50%	98.0%	0.4	64.0	
W010	Herbaceuous	B	62.0	0.00	0.17	2.02%	100.0%	1.3	65.2	**65.2**
W011	Developed, Open Space	C	74.0	0.01	0.05	29.97%	30.0%	22.2	22.2	
W011	Developed, Open Space	D	80.0	0.00	0.05	0.53%	30.5%	0.4	22.6	
W011	Developed, Low Intensity	C	80.0	0.00	0.05	2.97%	33.5%	2.4	25.0	
W011	Shrub/Scrub	C	65.0	0.00	0.05	1.75%	35.2%	1.1	26.1	
W011	Woody Wetlands	C	78.0	0.00	0.05	4.99%	40.2%	3.9	30.0	
W011	Woody Wetlands	D	78.0	0.01	0.05	27.23%	67.5%	21.2	51.3	
W011	Hay/Pasture	C	74.0	0.01	0.05	28.19%	95.6%	20.9	72.1	
W011	Hay/Pasture	D	80.0	0.00	0.05	4.36%	100.0%	3.5	75.6	**75.6**
W012	Developed, Open Space	C	74.0	0.00	0.02	1.31%	1.3%	1.0	1.0	
W012	Developed, Open Space	D	80.0	0.00	0.02	6.55%	7.9%	5.2	6.2	
W012	Developed, Low Intensity	D	85.0	0.00	0.02	0.89%	8.8%	0.8	7.0	
W012	Woody Wetlands	C	78.0	0.00	0.02	4.36%	13.1%	3.4	10.4	
W012	Woody Wetlands	D	78.0	0.02	0.02	81.29%	94.4%	63.4	73.8	
W012	Hay/Pasture	D	80.0	0.00	0.02	4.32%	98.7%	3.5	77.2	
W012	POS	C	74.0	0.00	0.02	0.08%	98.8%	0.1	77.3	
W012	POS	D	80.0	0.00	0.02	1.19%	100.0%	1.0	78.2	**78.2**
W0121	Developed, Open Space	C	74.0	0.18	0.62	29.15%	29.2%	21.6	21.6	
W0121	Developed, Open Space	B	61.0	0.01	0.62	2.37%	31.5%	1.4	23.0	
W0121	Developed, Open Space	D	80.0	0.00	0.62	0.03%	31.6%	0.0	23.0	
W0121	Developed, Low Intensity	C	80.0	0.03	0.62	4.62%	36.2%	3.7	26.7	
W0121	Shrub/Scrub	C	65.0	0.24	0.62	38.03%	74.2%	24.7	51.5	
W0121	Shrub/Scrub	B	48.0	0.11	0.62	18.50%	92.7%	8.9	60.3	
W0121	Woody Wetlands	C	78.0	0.01	0.62	1.56%	94.3%	1.2	61.6	

BASIN	LAND USE CATEGORY	SOIL MAP UNIT #	SUBREGION CN	SUBREGION AREA (mi^2)	SUBBASIN AREA (mi^2)	PERCENT OF SUBBASIN	CUMULATIVE PERCENT	AREA-WEIGHTED CN	CUMULATIVE CN	COMPOSITE CN
W0121	Woody Wetlands	D	78.0	0.00	0.62	0.79%	95.1%	0.6	62.2	
W0121	Hay/Pasture	C	74.0	0.01	0.62	1.37%	96.4%	1.0	63.2	
W0121	Hay/Pasture	B	61.0	0.00	0.62	0.06%	96.5%	0.0	63.2	
W0121	Herbaceuous	C	74.0	0.01	0.62	2.12%	98.6%	1.6	64.8	
W0121	Herbaceuous	B	62.0	0.01	0.62	1.39%	100.0%	0.9	65.7	**65.7**
W0122	Developed, Open Space	C	74.0	0.38	2.52	15.09%	15.1%	11.2	11.2	
W0122	Developed, Open Space	B	61.0	0.05	2.52	2.01%	17.1%	1.2	12.4	
W0122	Developed, Low Intensity	C	80.0	0.03	2.52	1.19%	18.3%	0.9	13.3	
W0122	Deciduous Forest	C	70.0	0.00	2.52	0.08%	18.4%	0.1	13.4	
W0122	Deciduous Forest	A	30.0	0.01	2.52	0.26%	18.6%	0.1	13.5	
W0122	Deciduous Forest	B	55.0	0.00	2.52	0.18%	18.8%	0.1	13.6	
W0122	Evergreen Forest	C	70.0	0.03	2.52	1.05%	19.9%	0.7	14.3	
W0122	Evergreen Forest	A	30.0	0.42	2.52	16.63%	36.5%	5.0	19.3	
W0122	Evergreen Forest	B	55.0	0.33	2.52	13.05%	49.5%	7.2	26.5	
W0122	Evergreen Forest	D	77.0	0.19	2.52	7.35%	56.9%	5.7	32.1	
W0122	Mixed Forest	C	70.0	0.00	2.52	0.02%	56.9%	0.0	32.2	
W0122	Mixed Forest	B	55.0	0.02	2.52	0.64%	57.5%	0.4	32.5	
W0122	Shrub/Scrub	C	65.0	0.26	2.52	10.46%	68.0%	6.8	39.3	
W0122	Shrub/Scrub	A	30.0	0.02	2.52	0.61%	68.6%	0.2	39.5	
W0122	Shrub/Scrub	B	48.0	0.20	2.52	7.89%	76.5%	3.8	43.3	
W0122	Shrub/Scrub	D	73.0	0.00	2.52	0.03%	76.5%	0.0	43.3	
W0122	Grassland/Herbaceous	C	74.0	0.00	2.52	0.10%	76.6%	0.1	43.4	
W0122	Grassland/Herbaceous	B	62.0	0.00	2.52	0.07%	76.7%	0.0	43.4	
W0122	Cultivated Crops	C	81.0	0.04	2.52	1.40%	78.1%	1.1	44.5	
W0122	Cultivated Crops	B	72.0	0.02	2.52	0.67%	78.8%	0.5	45.0	
W0122	Woody Wetlands	C	78.0	0.00	2.52	0.04%	78.8%	0.0	45.1	
W0122	Woody Wetlands	B	78.0	0.00	2.52	0.14%	78.9%	0.1	45.2	
W0122	Hay/Pasture	C	74.0	0.32	2.52	12.48%	91.4%	9.2	54.4	
W0122	Hay/Pasture	A	39.0	0.00	2.52	0.01%	91.4%	0.0	54.4	
W0122	Hay/Pasture	B	61.0	0.17	2.52	6.85%	98.3%	4.2	58.6	
W0122	Herbaceuous	C	74.0	0.03	2.52	1.38%	99.7%	1.0	59.6	
W0122	Herbaceuous	B	62.0	0.01	2.52	0.31%	100.0%	0.2	59.8	
W0122	Evergreen Forest	A	30.0	0.00	2.52	0.01%	100.0%	0.0	59.8	
W0122	Evergreen Forest	B	55.0	0.00	2.52	0.01%	100.0%	0.0	59.8	
W0122	Evergreen Forest	B	55.0	0.00	2.52	0.01%	100.0%	0.0	59.8	
W0122	Evergreen Forest	D	77.0	0.00	2.52	0.01%	100.0%	0.0	59.8	
W0122	Shrub/Scrub	A	30.0	0.00	2.52	0.00%	100.0%	0.0	59.8	
W0122	Shrub/Scrub	D	73.0	0.00	2.52	0.00%	100.0%	0.0	59.8	
W0122	Shrub/Scrub	B	48.0	0.00	2.52	0.00%	100.0%	0.0	59.8	
W0122	Shrub/Scrub	D	73.0	0.00	2.52	0.00%	100.0%	0.0	59.8	**59.8**
W0123	Developed, Open Space	C	74.0	0.03	1.65	1.67%	1.7%	1.2	1.2	
W0123	Developed, Open Space	B	61.0	0.01	1.65	0.78%	2.5%	0.5	1.7	
W0123	Developed, Low Intensity	C	80.0	0.00	1.65	0.27%	2.7%	0.2	1.9	
W0123	Developed, Low Intensity	B	70.0	0.00	1.65	0.03%	2.8%	0.0	2.0	
W0123	Deciduous Forest	C	70.0	0.01	1.65	0.85%	3.6%	0.6	2.5	
W0123	Deciduous Forest	A	30.0	0.02	1.65	0.94%	4.5%	0.3	2.8	
W0123	Deciduous Forest	B	55.0	0.03	1.65	1.91%	6.4%	1.1	3.9	
W0123	Evergreen Forest	C	70.0	0.05	1.65	2.78%	9.2%	1.9	5.8	
W0123	Evergreen Forest	A	30.0	0.58	1.65	35.50%	44.7%	10.7	16.5	
W0123	Evergreen Forest	B	55.0	0.49	1.65	29.79%	74.5%	16.4	32.9	
W0123	Shrub/Scrub	C	65.0	0.13	1.65	8.01%	82.5%	5.2	38.1	
W0123	Shrub/Scrub	A	30.0	0.01	1.65	0.38%	82.9%	0.1	38.2	
W0123	Shrub/Scrub	B	48.0	0.13	1.65	7.60%	90.5%	3.6	41.8	
W0123	Grassland/Herbaceous	C	74.0	0.06	1.65	3.51%	94.0%	2.6	44.4	
W0123	Grassland/Herbaceous	B	62.0	0.01	1.65	0.34%	94.4%	0.2	44.6	
W0123	Pasture/Hay	C	74.0	0.04	1.65	2.58%	96.9%	1.9	46.5	
W0123	Pasture/Hay	B	61.0	0.01	1.65	0.59%	97.5%	0.4	46.9	
W0123	Woody Wetlands	C	78.0	0.01	1.65	0.47%	98.0%	0.4	47.3	
W0123	Woody Wetlands	B	78.0	0.01	1.65	0.38%	98.4%	0.3	47.6	
W0123	Hay/Pasture	C	74.0	0.01	1.65	0.33%	98.7%	0.2	47.8	
W0123	Hay/Pasture	B	61.0	0.01	1.65	0.53%	99.2%	0.3	48.1	
W0123	Herbaceuous	C	74.0	0.01	1.65	0.37%	99.6%	0.3	48.4	
W0123	Emergent Herbaceous Wetlands	C	78.0	0.00	1.65	0.20%	99.8%	0.2	48.6	
W0123	Emergent Herbaceous Wetlands	B	78.0	0.00	1.65	0.18%	100.0%	0.1	48.7	
W0123	Evergreen Forest	A	30.0	0.00	1.65	0.01%	100.0%	0.0	48.7	
W0123	Evergreen Forest	B	55.0	0.00	1.65	0.01%	100.0%	0.0	48.7	**48.7**
W0124	Deciduous Forest	C	70.0	0.02	2.03	1.02%	1.0%	0.7	0.7	
W0124	Deciduous Forest	A	30.0	0.03	2.03	1.59%	2.6%	0.5	1.2	
W0124	Deciduous Forest	B	55.0	0.01	2.03	0.67%	3.3%	0.4	1.6	
W0124	Evergreen Forest	C	70.0	0.27	2.03	13.26%	16.5%	9.3	10.8	
W0124	Evergreen Forest	A	30.0	0.53	2.03	26.28%	42.8%	7.9	18.7	
W0124	Evergreen Forest	B	55.0	1.02	2.03	50.19%	93.0%	27.6	46.3	
W0124	Mixed Forest	B	55.0	0.01	2.03	0.31%	93.3%	0.2	46.5	
W0124	Shrub/Scrub	C	65.0	0.04	2.03	1.82%	95.1%	1.2	47.7	
W0124	Shrub/Scrub	A	30.0	0.01	2.03	0.71%	95.8%	0.2	47.9	
W0124	Shrub/Scrub	B	48.0	0.08	2.03	4.12%	100.0%	2.0	49.9	
W0124	Grassland/Herbaceous	B	62.0	0.00	2.03	0.02%	100.0%	0.0	49.9	
W0124	Evergreen Forest	C	70.0	0.00	2.03	0.01%	100.0%	0.0	49.9	
W0124	Evergreen Forest	B	55.0	0.00	2.03	0.01%	100.0%	0.0	49.9	
W0124	Evergreen Forest	A	30.0	0.00	2.03	0.01%	100.0%	0.0	49.9	
W0124	Evergreen Forest	B	55.0	0.00	2.03	0.01%	100.0%	0.0	49.9	**49.9**
W013	Developed, Open Space	C	74.0	0.02	0.08	20.73%	20.7%	15.3	15.3	
W013	Developed, Open Space	B	61.0	0.00	0.08	3.40%	24.1%	2.1	17.4	
W013	Developed, Open Space	D	80.0	0.00	0.08	5.35%	29.5%	4.3	21.7	
W013	Developed, Low Intensity	C	80.0	0.00	0.08	1.81%	31.3%	1.5	23.1	
W013	Developed, Low Intensity	D	85.0	0.00	0.08	0.23%	31.5%	0.2	23.3	
W013	Shrub/Scrub	C	65.0	0.00	0.08	0.14%	31.7%	0.1	23.4	
W013	Shrub/Scrub	B	48.0	0.00	0.08	0.30%	32.0%	0.1	23.6	
W013	Shrub/Scrub	D	73.0	0.00	0.08	3.16%	35.1%	2.3	25.9	
W013	Cultivated Crops	C	81.0	0.00	0.08	0.55%	35.7%	0.4	26.3	
W013	Cultivated Crops	B	72.0	0.00	0.08	5.04%	40.7%	3.6	30.0	
W013	Cultivated Crops	D	85.0	0.00	0.08	3.96%	44.7%	3.4	33.3	
W013	Woody Wetlands	C	78.0	0.00	0.08	0.71%	45.4%	0.6	33.9	
W013	Woody Wetlands	B	78.0	0.00	0.08	0.01%	45.4%	0.0	33.9	
W013	Woody Wetlands	D	78.0	0.02	0.08	21.03%	66.4%	16.4	50.3	
W013	Hay/Pasture	C	74.0	0.01	0.08	14.84%	81.3%	11.0	61.3	
W013	Hay/Pasture	B	61.0	0.01	0.08	16.41%	97.7%	10.0	71.3	

BASIN	LAND USE CATEGORY	SOIL MAP UNIT #	SUBREGION CN	SUBREGION AREA (mi^2)	SUBBASIN AREA (mi^2)	PERCENT OF SUBBASIN	CUMULATIVE PERCENT	AREA-WEIGHTED CN	CUMULATIVE CN	COMPOSITE CN
W013	Hay/Pasture	D	80.0	0.00	0.08	1.95%	99.6%	1.6	72.9	
W013	ROW	C	98.0	0.00	0.08	0.00%	99.6%	0.0	72.9	
W013	ROW	D	98.0	0.00	0.08	0.04%	99.7%	0.0	72.9	
W013	Emergent Herbaceous Wetlands	D	78.0	0.00	0.08	0.32%	100.0%	0.2	73.1	**73.1**
W014	Developed, Open Space	C	74.0	0.00	0.11	0.80%	0.8%	0.6	0.6	
W014	Developed, Open Space	B	61.0	0.00	0.11	2.86%	3.7%	1.7	2.3	
W014	Shrub/Scrub	B	48.0	0.00	0.11	0.00%	3.7%	0.0	2.3	
W014	Shrub/Scrub	D	73.0	0.00	0.11	0.05%	3.7%	0.0	2.4	
W014	Cultivated Crops	C	81.0	0.01	0.11	10.17%	13.9%	8.2	10.6	
W014	Cultivated Crops	B	72.0	0.01	0.11	6.42%	20.3%	4.6	15.2	
W014	Woody Wetlands	B	78.0	0.00	0.11	0.26%	20.6%	0.2	15.4	
W014	Woody Wetlands	D	78.0	0.01	0.11	6.38%	26.9%	5.0	20.4	
W014	Hay/Pasture	C	74.0	0.02	0.11	16.21%	43.1%	12.0	32.4	
W014	Hay/Pasture	B	61.0	0.05	0.11	51.55%	94.7%	31.4	63.8	
W014	Hay/Pasture	D	80.0	0.01	0.11	5.31%	100.0%	4.2	68.1	**68.1**
W0141	Developed, Open Space	C	74.0	0.00	0.13	1.40%	1.4%	1.0	1.0	
W0141	Developed, Low Intensity	C	80.0	0.00	0.13	0.51%	1.9%	0.4	1.4	
W0141	Shrub/Scrub	C	65.0	0.00	0.13	0.01%	1.9%	0.0	1.4	
W0141	Cultivated Crops	C	81.0	0.01	0.13	6.15%	8.1%	5.0	6.4	
W0141	Woody Wetlands	C	78.0	0.00	0.13	0.77%	8.8%	0.6	7.0	
W0141	Woody Wetlands	D	78.0	0.00	0.13	0.41%	9.3%	0.3	7.4	
W0141	Hay/Pasture	C	74.0	0.12	0.13	90.02%	99.3%	66.6	74.0	
W0141	Hay/Pasture	D	80.0	0.00	0.13	0.73%	100.0%	0.6	74.6	**74.6**
W015	Deciduous Forest	D	77.0	0.00	0.01	10.10%	10.1%	7.8	7.8	
W015	Woody Wetlands	B	78.0	0.00	0.01	1.57%	11.7%	1.2	9.0	
W015	Woody Wetlands	D	78.0	0.00	0.01	35.01%	46.7%	27.3	36.3	
W015	Hay/Pasture	C	74.0	0.00	0.01	25.73%	72.4%	19.0	55.3	
W015	Hay/Pasture	D	80.0	0.00	0.01	27.59%	100.0%	22.1	77.4	**77.4**
W0151	Developed, Open Space	C	74.0	0.00	0.17	0.29%	0.3%	0.2	0.2	
W0151	Developed, Open Space	B	61.0	0.00	0.17	0.10%	0.4%	0.1	0.3	
W0151	Deciduous Forest	C	70.0	0.00	0.17	0.05%	0.4%	0.0	0.3	
W0151	Deciduous Forest	B	55.0	0.00	0.17	0.11%	0.6%	0.1	0.4	
W0151	Deciduous Forest	D	77.0	0.00	0.17	0.85%	1.4%	0.7	1.0	
W0151	Shrub/Scrub	C	65.0	0.00	0.17	0.95%	2.4%	0.6	1.6	
W0151	Shrub/Scrub	D	73.0	0.00	0.17	0.92%	3.3%	0.7	2.3	
W0151	Cultivated Crops	C	81.0	0.08	0.17	47.65%	50.9%	38.6	40.9	
W0151	Cultivated Crops	B	72.0	0.00	0.17	0.10%	51.0%	0.1	41.0	
W0151	Cultivated Crops	D	85.0	0.00	0.17	0.09%	51.1%	0.1	41.1	
W0151	Woody Wetlands	C	78.0	0.00	0.17	0.18%	51.3%	0.1	41.2	
W0151	Woody Wetlands	B	78.0	0.00	0.17	0.34%	51.6%	0.3	41.5	
W0151	Woody Wetlands	D	78.0	0.00	0.17	1.99%	53.6%	1.6	43.0	
W0151	Hay/Pasture	C	74.0	0.07	0.17	40.53%	94.2%	30.0	73.0	
W0151	Hay/Pasture	B	61.0	0.00	0.17	2.74%	96.9%	1.7	74.7	
W0151	Hay/Pasture	D	80.0	0.01	0.17	3.09%	100.0%	2.5	77.2	**77.2**
W016	Developed, Open Space	C	74.0	0.01	0.25	2.42%	2.4%	1.8	1.8	
W016	Developed, Open Space	D	80.0	0.00	0.25	1.50%	3.9%	1.2	3.0	
W016	Developed, Low Intensity	C	80.0	0.00	0.25	0.54%	4.5%	0.4	3.4	
W016	Developed, Low Intensity	D	85.0	0.00	0.25	0.50%	5.0%	0.4	3.8	
W016	Deciduous Forest	C	70.0	0.00	0.25	0.01%	5.0%	0.0	3.8	
W016	Deciduous Forest	B	55.0	0.00	0.25	0.27%	5.2%	0.1	4.0	
W016	Deciduous Forest	D	77.0	0.01	0.25	2.63%	7.9%	2.0	6.0	
W016	Cultivated Crops	C	81.0	0.07	0.25	27.76%	35.6%	22.5	28.5	
W016	Cultivated Crops	B	72.0	0.02	0.25	6.47%	42.1%	4.7	33.2	
W016	Cultivated Crops	D	85.0	0.00	0.25	0.20%	42.3%	0.2	33.3	
W016	Woody Wetlands	C	78.0	0.00	0.25	0.45%	42.7%	0.4	33.7	
W016	Woody Wetlands	B	78.0	0.01	0.25	3.50%	46.2%	2.7	36.4	
W016	Woody Wetlands	D	78.0	0.04	0.25	15.32%	61.6%	11.9	48.4	
W016	Hay/Pasture	C	74.0	0.03	0.25	12.03%	73.6%	8.9	57.3	
W016	Hay/Pasture	B	61.0	0.04	0.25	15.11%	88.7%	9.2	66.5	
W016	Hay/Pasture	D	80.0	0.01	0.25	5.51%	94.2%	4.4	70.9	
W016	Herbaceuous	B	62.0	0.00	0.25	1.90%	96.1%	1.2	72.1	
W016	Emergent Herbaceous Wetlands	B	78.0	0.01	0.25	2.87%	99.0%	2.2	74.3	
W016	Emergent Herbaceous Wetlands	D	78.0	0.00	0.25	1.01%	100.0%	0.8	75.1	**75.1**
W017	Developed, Open Space	C	74.0	0.01	0.28	2.55%	2.5%	1.9	1.9	
W017	Developed, Open Space	B	61.0	0.01	0.28	2.85%	5.4%	1.7	3.6	
W017	Developed, Open Space	D	80.0	0.01	0.28	1.94%	7.3%	1.6	5.2	
W017	Deciduous Forest	C	70.0	0.00	0.28	0.02%	7.4%	0.0	5.2	
W017	Deciduous Forest	B	55.0	0.00	0.28	0.07%	7.4%	0.0	5.2	
W017	Deciduous Forest	D	77.0	0.00	0.28	1.53%	9.0%	1.2	6.4	
W017	Evergreen Forest	C	70.0	0.00	0.28	0.40%	9.4%	0.3	6.7	
W017	Evergreen Forest	B	55.0	0.02	0.28	8.82%	18.2%	4.9	11.5	
W017	Cultivated Crops	C	81.0	0.11	0.28	40.75%	58.9%	33.0	44.5	
W017	Cultivated Crops	B	72.0	0.04	0.28	13.62%	72.5%	9.8	54.3	
W017	Cultivated Crops	D	85.0	0.01	0.28	4.24%	76.8%	3.6	58.0	
W017	Woody Wetlands	C	78.0	0.00	0.28	0.35%	77.1%	0.3	58.2	
W017	Woody Wetlands	B	78.0	0.00	0.28	1.02%	78.2%	0.8	59.0	
W017	Woody Wetlands	D	78.0	0.02	0.28	7.24%	85.4%	5.6	64.7	
W017	Hay/Pasture	C	74.0	0.01	0.28	4.52%	89.9%	3.3	68.0	
W017	Hay/Pasture	B	61.0	0.01	0.28	3.13%	93.0%	1.9	69.9	
W017	Hay/Pasture	D	80.0	0.01	0.28	3.54%	96.6%	2.8	72.8	
W017	Herbaceuous	C	74.0	0.00	0.28	0.95%	97.5%	0.7	73.5	
W017	Herbaceuous	B	62.0	0.00	0.28	0.84%	98.4%	0.5	74.0	
W017	Emergent Herbaceous Wetlands	B	78.0	0.00	0.28	0.70%	99.1%	0.5	74.5	
W017	Emergent Herbaceous Wetlands	D	78.0	0.00	0.28	0.93%	100.0%	0.7	75.2	**75.2**
W02	CA	C	94.0	0.00	0.07	6.39%	6.4%	6.0	6.0	
W02	CR	C	94.0	0.00	0.07	1.73%	8.1%	1.6	7.6	
W02	LM	C	94.0	0.03	0.07	35.42%	43.5%	33.3	40.9	
W02	PFP	C	0.0	0.00	0.07	0.01%	43.5%	0.0	40.9	
W02	ROW	C	98.0	0.03	0.07	48.49%	92.0%	47.5	88.5	
W02	ROW	D	98.0	0.00	0.07	3.36%	95.4%	3.3	91.7	
W02	SFR	C	83.0	0.00	0.07	3.83%	99.2%	3.2	94.9	
W02	VACANT	C	91.0	0.00	0.07	0.77%	100.0%	0.7	95.6	**95.6**
W021	AP	C	90.0	0.00	0.09	1.93%	1.9%	1.7	1.7	
W021	CA	C	94.0	0.00	0.09	3.58%	5.5%	3.4	5.1	
W021	CR	C	94.0	0.01	0.09	10.87%	16.4%	10.2	15.3	
W021	DTR	C	90.0	0.00	0.09	1.54%	17.9%	1.4	16.7	
W021	HM	C	94.0	0.00	0.09	1.30%	19.2%	1.2	17.9	

BASIN	LAND USE CATEGORY	SOIL MAP UNIT #	SUBREGION CN	SUBREGION AREA (mi^2)	SUBBASIN AREA (mi^2)	PERCENT OF SUBBASIN	CUMULATIVE PERCENT	AREA-WEIGHTED CN	CUMULATIVE CN	COMPOSITE CN
W021	LM	C	94.0	0.01	0.09	11.43%	30.7%	10.7	28.7	
W021	MFR	C	90.0	0.00	0.09	3.02%	33.7%	2.7	31.4	
W021	MIXED	C	84.0	0.00	0.09	4.37%	38.0%	3.7	35.1	
W021	PFP	C	0.0	0.00	0.09	0.01%	38.1%	0.0	35.1	
W021	POS	C	74.0	0.00	0.09	1.76%	39.8%	1.3	36.4	
W021	POS	D	80.0	0.00	0.09	0.12%	39.9%	0.1	36.5	
W021	RB	C	94.0	0.00	0.09	0.18%	40.1%	0.2	36.6	
W021	ROW	C	98.0	0.03	0.09	30.35%	70.5%	29.7	66.4	
W021	ROW	D	98.0	0.00	0.09	0.15%	70.6%	0.1	66.5	
W021	SFR	C	83.0	0.03	0.09	27.60%	98.2%	22.9	89.4	
W021	VACANT	C	91.0	0.00	0.09	1.77%	100.0%	1.6	91.1	**91.1**
W022	AP	C	90.0	0.01	0.28	4.92%	4.9%	4.4	4.4	
W022	CA	C	94.0	0.00	0.28	1.61%	6.5%	1.5	5.9	
W022	CHURCH	C	94.0	0.00	0.28	0.71%	7.2%	0.7	6.6	
W022	CR	C	94.0	0.01	0.28	2.75%	10.0%	2.6	9.2	
W022	DTR	C	90.0	0.02	0.28	8.30%	18.3%	7.5	16.7	
W022	DTR	B	85.0	0.00	0.28	0.00%	18.3%	0.0	16.7	
W022	HM	C	94.0	0.01	0.28	3.52%	21.8%	3.3	20.0	
W022	LM	C	94.0	0.00	0.28	0.16%	22.0%	0.2	20.1	
W022	MFR	C	90.0	0.01	0.28	4.59%	26.6%	4.1	24.3	
W022	MFR	B	85.0	0.00	0.28	0.26%	26.8%	0.2	24.5	
W022	MHMP	C	90.0	0.00	0.28	0.27%	27.1%	0.2	24.7	
W022	MIXED	C	84.0	0.00	0.28	0.69%	27.8%	0.6	25.3	
W022	PFP	C	0.0	0.01	0.28	3.82%	31.6%	0.0	25.3	
W022	POS	C	74.0	0.01	0.28	2.88%	34.5%	2.1	27.4	
W022	RB	C	94.0	0.00	0.28	0.59%	35.1%	0.6	28.0	
W022	ROW	C	98.0	0.08	0.28	29.87%	64.9%	29.3	57.3	
W022	ROW	B	98.0	0.00	0.28	0.66%	65.6%	0.6	57.9	
W022	SEF	C	86.0	0.00	0.28	1.38%	67.0%	1.2	59.1	
W022	SFR	C	83.0	0.09	0.28	32.93%	99.9%	27.3	86.4	
W022	SFR	B	75.0	0.00	0.28	0.07%	100.0%	0.1	86.5	
W022	UDV	B	75.0	0.00	0.28	0.02%	100.0%	0.0	86.5	**86.5**
W030	CR	C	94.0	0.00	0.02	4.47%	4.5%	4.2	4.2	
W030	DTR	C	90.0	0.00	0.02	0.98%	5.5%	0.9	5.1	
W030	HM	C	94.0	0.00	0.02	0.23%	5.7%	0.2	5.3	
W030	LM	C	94.0	0.00	0.02	19.67%	25.3%	18.5	23.8	
W030	MIXED	C	84.0	0.00	0.02	17.24%	42.6%	14.5	38.3	
W030	PFP	C	0.0	0.00	0.02	1.46%	44.0%	0.0	38.3	
W030	RB	C	94.0	0.00	0.02	1.39%	45.4%	1.3	39.6	
W030	ROW	C	98.0	0.00	0.02	20.92%	66.4%	20.5	60.1	
W030	SFR	C	83.0	0.01	0.02	28.07%	94.4%	23.3	83.4	
W030	VACANT	C	91.0	0.00	0.02	5.58%	100.0%	5.1	88.4	**88.4**
W031	AP	C	90.0	0.00	0.08	2.12%	2.1%	1.9	1.9	
W031	CA	C	94.0	0.00	0.08	1.09%	3.2%	1.0	2.9	
W031	CR	C	94.0	0.01	0.08	7.08%	10.3%	6.7	9.6	
W031	DTR	C	90.0	0.01	0.08	9.20%	19.5%	8.3	17.9	
W031	MFR	C	90.0	0.00	0.08	4.92%	24.4%	4.4	22.3	
W031	MIXED	C	84.0	0.00	0.08	2.07%	26.5%	1.7	24.0	
W031	PFP	C	0.0	0.00	0.08	2.49%	29.0%	0.0	24.0	
W031	POS	C	74.0	0.00	0.08	4.19%	33.2%	3.1	27.1	
W031	ROW	C	98.0	0.02	0.08	31.49%	64.7%	30.9	58.0	
W031	SFR	C	83.0	0.03	0.08	35.20%	99.9%	29.2	87.2	
W031	VACANT	C	91.0	0.00	0.08	0.14%	100.0%	0.1	87.3	**87.3**
W04	AP	C	90.0	0.01	0.09	5.64%	5.6%	5.1	5.1	
W04	CA	C	94.0	0.00	0.09	1.32%	7.0%	1.2	6.3	
W04	CHURCH	C	94.0	0.00	0.09	0.43%	7.4%	0.4	6.7	
W04	CR	C	94.0	0.00	0.09	3.79%	11.2%	3.6	10.3	
W04	DTR	C	90.0	0.01	0.09	5.88%	17.1%	5.3	15.6	
W04	LM	C	94.0	0.00	0.09	0.80%	17.9%	0.8	16.3	
W04	MFR	C	90.0	0.01	0.09	10.24%	28.1%	9.2	25.6	
W04	MIXED	C	84.0	0.00	0.09	4.80%	32.9%	4.0	29.6	
W04	PFP	C	0.0	0.00	0.09	2.75%	35.7%	0.0	29.6	
W04	POS	C	74.0	0.01	0.09	6.18%	41.8%	4.6	34.2	
W04	RB	C	94.0	0.00	0.09	0.31%	42.1%	0.3	34.4	
W04	ROW	C	98.0	0.03	0.09	29.73%	71.9%	29.1	63.6	
W04	SEF	C	86.0	0.00	0.09	4.40%	76.3%	3.8	67.4	
W04	SFR	C	83.0	0.02	0.09	22.90%	99.2%	19.0	86.4	
W04	VACANT	C	91.0	0.00	0.09	0.82%	100.0%	0.7	87.1	**87.1**
W041	AP	C	90.0	0.01	0.67	0.96%	1.0%	0.9	0.9	
W041	CA	C	94.0	0.00	0.67	0.05%	1.0%	0.0	0.9	
W041	CHURCH	C	94.0	0.01	0.67	1.30%	2.3%	1.2	2.1	
W041	CR	C	94.0	0.02	0.67	2.33%	4.6%	2.2	4.3	
W041	DTR	C	90.0	0.07	0.67	9.78%	14.4%	8.8	13.1	
W041	HM	C	94.0	0.00	0.67	0.24%	14.7%	0.2	13.4	
W041	LM	C	94.0	0.00	0.67	0.01%	14.7%	0.0	13.4	
W041	MFR	C	90.0	0.05	0.67	7.20%	21.9%	6.5	19.8	
W041	MIXED	C	84.0	0.01	0.67	2.03%	23.9%	1.7	21.6	
W041	PFP	C	0.0	0.01	0.67	1.20%	25.1%	0.0	21.6	
W041	POS	C	74.0	0.01	0.67	1.39%	26.5%	1.0	22.6	
W041	RB	C	94.0	0.00	0.67	0.15%	26.7%	0.1	22.7	
W041	ROW	C	98.0	0.20	0.67	29.36%	56.0%	28.8	51.5	
W041	ROW	B	98.0	0.00	0.67	0.00%	56.0%	0.0	51.5	
W041	ROW	D	98.0	0.00	0.67	0.03%	56.0%	0.0	51.5	
W041	SEF	C	86.0	0.08	0.67	12.57%	68.6%	10.8	62.3	
W041	SFR	C	83.0	0.20	0.67	29.78%	98.4%	24.7	87.1	
W041	SFR	D	87.0	0.00	0.67	0.02%	98.4%	0.0	87.1	
W041	VACANT	C	91.0	0.01	0.67	1.59%	100.0%	1.4	88.5	**88.5**
W05	AP	C	90.0	0.00	0.02	4.24%	4.2%	3.8	3.8	
W05	CR	C	94.0	0.00	0.02	19.32%	23.6%	18.2	22.0	
W05	DTR	C	90.0	0.00	0.02	5.82%	29.4%	5.2	27.2	
W05	MFR	C	90.0	0.00	0.02	0.43%	29.8%	0.4	27.6	
W05	MIXED	C	84.0	0.00	0.02	11.65%	41.4%	9.8	37.4	
W05	PFP	C	0.0	0.00	0.02	2.39%	43.8%	0.0	37.4	
W05	POS	C	74.0	0.00	0.02	1.60%	45.4%	1.2	38.6	
W05	RB	C	94.0	0.00	0.02	4.75%	50.2%	4.5	43.0	
W05	ROW	C	98.0	0.01	0.02	31.93%	82.1%	31.3	74.3	
W05	SFR	C	83.0	0.00	0.02	17.89%	100.0%	14.8	89.2	**89.2**

BASIN	LAND USE CATEGORY	SOIL MAP UNIT #	SUBREGION CN	SUBREGION AREA (mi^2)	SUBBASIN AREA (mi^2)	PERCENT OF SUBBASIN	CUMULATIVE PERCENT	AREA-WEIGHTED CN	CUMULATIVE CN	COMPOSITE CN
W06	CR	C	94.0	0.00	0.04	0.11%	0.1%	0.1	0.1	
W06	DTR	C	90.0	0.00	0.04	8.55%	8.7%	7.7	7.8	
W06	LM	C	94.0	0.00	0.04	0.44%	9.1%	0.4	8.2	
W06	MFR	C	90.0	0.00	0.04	9.78%	18.9%	8.8	17.0	
W06	POS	C	74.0	0.01	0.04	21.03%	39.9%	15.6	32.6	
W06	ROW	C	98.0	0.01	0.04	13.10%	53.0%	12.8	45.4	
W06	SFR	C	83.0	0.02	0.04	46.99%	100.0%	39.0	84.4	**84.4**
W07	Developed, Open Space	C	74.0	0.00	0.18	0.11%	0.1%	0.1	0.1	
W07	Developed, Open Space	B	61.0	0.01	0.18	7.38%	7.5%	4.5	4.6	
W07	Developed, Open Space	D	80.0	0.00	0.18	0.29%	7.8%	0.2	4.8	
W07	Developed, Low Intensity	B	70.0	0.00	0.18	0.05%	7.8%	0.0	4.8	
W07	CR	C	94.0	0.00	0.18	0.92%	8.7%	0.9	5.7	
W07	DTR	C	90.0	0.01	0.18	2.77%	11.5%	2.5	8.2	
W07	LM	C	94.0	0.00	0.18	0.62%	12.1%	0.6	8.8	
W07	MFR	C	90.0	0.00	0.18	1.49%	13.6%	1.3	10.1	
W07	MFR	B	85.0	0.00	0.18	0.41%	14.0%	0.3	10.5	
W07	MFR	D	92.0	0.00	0.18	0.20%	14.2%	0.2	10.7	
W07	MIXED	C	84.0	0.01	0.18	5.32%	19.6%	4.5	15.1	
W07	MIXED	B	77.0	0.01	0.18	4.69%	24.2%	3.6	18.7	
W07	MIXED	D	88.0	0.00	0.18	1.95%	26.2%	1.7	20.5	
W07	POS	C	74.0	0.03	0.18	17.57%	43.8%	13.0	33.5	
W07	POS	B	61.0	0.00	0.18	1.29%	45.0%	0.8	34.2	
W07	POS	D	80.0	0.01	0.18	5.21%	50.3%	4.2	38.4	
W07	ROW	C	98.0	0.01	0.18	2.84%	53.1%	2.8	41.2	
W07	ROW	B	98.0	0.01	0.18	3.45%	56.5%	3.4	44.6	
W07	ROW	D	98.0	0.00	0.18	0.00%	56.5%	0.0	44.6	
W07	SFR	C	83.0	0.01	0.18	4.92%	61.5%	4.1	48.6	
W07	SFR	B	75.0	0.03	0.18	15.16%	76.6%	11.4	60.0	
W07	SFR	D	87.0	0.01	0.18	3.74%	80.4%	3.3	63.3	
W07	UDV	C	83.0	0.03	0.18	14.90%	95.3%	12.4	75.6	
W07	UDV	B	75.0	0.00	0.18	2.21%	97.5%	1.7	77.3	
W07	VACANT	C	91.0	0.00	0.18	2.13%	99.6%	1.9	79.2	
W07	VACANT	B	86.0	0.00	0.18	0.41%	100.0%	0.4	79.6	**79.6**
W08	Developed, Open Space	C	74.0	0.03	0.18	19.45%	19.5%	14.4	14.4	
W08	Developed, Open Space	B	61.0	0.02	0.18	8.59%	28.0%	5.2	19.6	
W08	Developed, Open Space	D	80.0	0.01	0.18	3.93%	32.0%	3.1	22.8	
W08	Developed, Low Intensity	C	80.0	0.00	0.18	2.74%	34.7%	2.2	25.0	
W08	Developed, Low Intensity	B	70.0	0.00	0.18	1.02%	35.7%	0.7	25.7	
W08	Developed, Low Intensity	D	85.0	0.00	0.18	0.52%	36.3%	0.4	26.1	
W08	Developed, Medium Intensity	C	83.0	0.00	0.18	0.10%	36.3%	0.1	26.2	
W08	Evergreen Forest	B	55.0	0.00	0.18	0.11%	36.5%	0.1	26.3	
W08	Evergreen Forest	D	77.0	0.00	0.18	1.07%	37.5%	0.8	27.1	
W08	Shrub/Scrub	B	48.0	0.00	0.18	1.39%	38.9%	0.7	27.8	
W08	Shrub/Scrub	D	73.0	0.00	0.18	1.33%	40.2%	1.0	28.7	
W08	Cultivated Crops	C	81.0	0.00	0.18	0.32%	40.6%	0.3	29.0	
W08	Woody Wetlands	C	78.0	0.00	0.18	0.12%	40.7%	0.1	29.1	
W08	Woody Wetlands	B	78.0	0.01	0.18	2.94%	43.6%	2.3	31.4	
W08	Woody Wetlands	D	78.0	0.01	0.18	3.85%	47.5%	3.0	34.4	
W08	DTR	B	85.0	0.00	0.18	0.47%	47.9%	0.4	34.8	
W08	GOLF	C	74.0	0.00	0.18	2.27%	50.2%	1.7	36.5	
W08	Hay/Pasture	C	74.0	0.01	0.18	5.05%	55.3%	3.7	40.2	
W08	Hay/Pasture	B	61.0	0.00	0.18	1.12%	56.4%	0.7	40.9	
W08	Hay/Pasture	D	80.0	0.00	0.18	2.21%	58.6%	1.8	42.6	
W08	MFR	C	90.0	0.00	0.18	1.38%	60.0%	1.2	43.9	
W08	POS	C	74.0	0.00	0.18	0.03%	60.0%	0.0	43.9	
W08	POS	B	61.0	0.00	0.18	0.44%	60.5%	0.3	44.2	
W08	ROW	C	98.0	0.00	0.18	1.85%	62.3%	1.8	46.0	
W08	ROW	B	98.0	0.02	0.18	8.60%	70.9%	8.4	54.4	
W08	ROW	D	98.0	0.00	0.18	0.19%	71.1%	0.2	54.6	
W08	SFR	C	83.0	0.01	0.18	3.65%	74.7%	3.0	57.6	
W08	SFR	B	75.0	0.02	0.18	14.18%	88.9%	10.6	68.3	
W08	SFR	D	87.0	0.00	0.18	0.02%	88.9%	0.0	68.3	
W08	UDV	C	83.0	0.00	0.18	0.02%	88.9%	0.0	68.3	
W08	UDV	B	75.0	0.00	0.18	1.66%	90.6%	1.2	69.5	
W08	UDV	D	87.0	0.00	0.18	0.77%	91.4%	0.7	70.2	
W08	VACANT	C	91.0	0.00	0.18	0.00%	91.4%	0.0	70.2	
W08	VACANT	B	86.0	0.01	0.18	6.33%	97.7%	5.4	75.7	
W08	Emergent Herbaceous Wetlands	B	78.0	0.00	0.18	1.96%	99.7%	1.5	77.2	
W08	Emergent Herbaceous Wetlands	D	78.0	0.00	0.18	0.33%	100.0%	0.3	77.4	**77.4**
W09	Developed, Open Space	C	74.0	0.12	0.36	33.87%	33.9%	25.1	25.1	
W09	Developed, Open Space	B	61.0	0.08	0.36	22.54%	56.4%	13.7	38.8	
W09	Developed, Open Space	D	80.0	0.01	0.36	3.79%	60.2%	3.0	41.8	
W09	Developed, Low Intensity	C	80.0	0.01	0.36	3.44%	63.6%	2.7	44.6	
W09	Developed, Low Intensity	B	70.0	0.00	0.36	1.36%	65.0%	1.0	45.5	
W09	Developed, Low Intensity	D	85.0	0.00	0.36	0.22%	65.2%	0.2	45.7	
W09	Deciduous Forest	C	70.0	0.00	0.36	0.94%	66.1%	0.7	46.4	
W09	Deciduous Forest	B	55.0	0.00	0.36	0.07%	66.2%	0.0	46.4	
W09	Deciduous Forest	D	77.0	0.00	0.36	0.77%	67.0%	0.6	47.0	
W09	Evergreen Forest	C	70.0	0.00	0.36	0.31%	67.3%	0.2	47.2	
W09	Evergreen Forest	D	77.0	0.00	0.36	0.26%	67.6%	0.2	47.4	
W09	Mixed Forest	C	70.0	0.00	0.36	0.74%	68.3%	0.5	48.0	
W09	Mixed Forest	B	55.0	0.00	0.36	0.43%	68.7%	0.2	48.2	
W09	Shrub/Scrub	C	65.0	0.03	0.36	7.10%	75.8%	4.6	52.8	
W09	Shrub/Scrub	B	48.0	0.02	0.36	5.42%	81.3%	2.6	55.4	
W09	Cultivated Crops	C	81.0	0.01	0.36	1.93%	83.2%	1.6	57.0	
W09	Cultivated Crops	B	72.0	0.00	0.36	0.00%	83.2%	0.0	57.0	
W09	Woody Wetlands	C	78.0	0.00	0.36	0.66%	83.9%	0.5	57.5	
W09	Woody Wetlands	D	78.0	0.00	0.36	1.27%	85.1%	1.0	58.5	
W09	Hay/Pasture	C	74.0	0.04	0.36	10.48%	95.6%	7.8	66.2	
W09	Hay/Pasture	B	61.0	0.00	0.36	0.34%	95.9%	0.2	66.4	
W09	Hay/Pasture	D	80.0	0.00	0.36	0.15%	96.1%	0.1	66.6	
W09	ROW	C	98.0	0.00	0.36	0.01%	96.1%	0.0	66.6	
W09	ROW	B	98.0	0.00	0.36	0.50%	96.6%	0.5	67.1	
W09	SFR	C	83.0	0.00	0.36	0.01%	96.6%	0.0	67.1	
W09	SFR	B	75.0	0.00	0.36	0.82%	97.4%	0.6	67.7	
W09	VACANT	B	86.0	0.00	0.36	0.12%	97.6%	0.1	67.8	
W09	Emergent Herbaceous Wetlands	C	78.0	0.01	0.36	1.96%	99.5%	1.5	69.3	

BASIN	LAND USE CATEGORY	SOIL MAP UNIT #	SUBREGION CN	SUBREGION AREA (mi^2)	SUBBASIN AREA (mi^2)	PERCENT OF SUBBASIN	CUMULATIVE PERCENT	AREA-WEIGHTED CN	CUMULATIVE CN	COMPOSITE CN
W09	Emergent Herbaceous Wetlands	D	78.0	0.00	0.36	0.49%	100.0%	0.4	69.7	**69.7**
W2070	Developed, Open Space	C	74.0	0.04	2.57	1.43%	1.4%	1.1	1.1	
W2070	Developed, Open Space	A	39.0	0.00	2.57	0.00%	1.4%	0.0	1.1	
W2070	Developed, Open Space	B	61.0	0.01	2.57	0.55%	2.0%	0.3	1.4	
W2070	Developed, Open Space	D	80.0	0.01	2.57	0.30%	2.3%	0.2	1.6	
W2070	Deciduous Forest	C	70.0	0.01	2.57	0.22%	2.5%	0.2	1.8	
W2070	Deciduous Forest	A	30.0	0.04	2.57	1.59%	4.1%	0.5	2.3	
W2070	Deciduous Forest	B	55.0	0.07	2.57	2.76%	6.9%	1.5	3.8	
W2070	Deciduous Forest	D	77.0	0.01	2.57	0.23%	7.1%	0.2	4.0	
W2070	Evergreen Forest	C	70.0	0.06	2.57	2.34%	9.4%	1.6	5.6	
W2070	Evergreen Forest	A	30.0	0.25	2.57	9.77%	19.2%	2.9	8.5	
W2070	Evergreen Forest	B	55.0	1.23	2.57	48.05%	67.3%	26.4	35.0	
W2070	Evergreen Forest	D	77.0	0.40	2.57	15.43%	82.7%	11.9	46.8	
W2070	Shrub/Scrub	C	65.0	0.16	2.57	6.07%	88.7%	3.9	50.8	
W2070	Shrub/Scrub	A	30.0	0.01	2.57	0.46%	89.2%	0.1	50.9	
W2070	Shrub/Scrub	B	48.0	0.08	2.57	3.19%	92.4%	1.5	52.5	
W2070	Shrub/Scrub	D	73.0	0.00	2.57	0.04%	92.4%	0.0	52.5	
W2070	Cultivated Crops	C	81.0	0.04	2.57	1.42%	93.9%	1.1	53.6	
W2070	Cultivated Crops	B	72.0	0.01	2.57	0.20%	94.1%	0.1	53.8	
W2070	Cultivated Crops	D	85.0	0.00	2.57	0.02%	94.1%	0.0	53.8	
W2070	Woody Wetlands	C	78.0	0.00	2.57	0.06%	94.1%	0.0	53.8	
W2070	Woody Wetlands	A	78.0	0.00	2.57	0.00%	94.1%	0.0	53.8	
W2070	Woody Wetlands	B	78.0	0.01	2.57	0.44%	94.6%	0.3	54.2	
W2070	Woody Wetlands	D	78.0	0.01	2.57	0.54%	95.1%	0.4	54.6	
W2070	Hay/Pasture	C	74.0	0.07	2.57	2.83%	97.9%	2.1	56.7	
W2070	Hay/Pasture	B	61.0	0.03	2.57	1.11%	99.1%	0.7	57.4	
W2070	Hay/Pasture	D	80.0	0.01	2.57	0.25%	99.3%	0.2	57.6	
W2070	Herbaceuous	C	74.0	0.01	2.57	0.54%	99.8%	0.4	58.0	
W2070	Herbaceuous	B	62.0	0.00	2.57	0.11%	99.9%	0.1	58.0	
W2070	Deciduous Forest	C	70.0	0.00	2.57	0.00%	100.0%	0.0	58.0	
W2070	Deciduous Forest	A	30.0	0.00	2.57	0.00%	100.0%	0.0	58.0	
W2070	Deciduous Forest	C	70.0	0.00	2.57	0.00%	100.0%	0.0	58.0	
W2070	Deciduous Forest	D	77.0	0.00	2.57	0.00%	100.0%	0.0	58.0	
W2070	Deciduous Forest	A	30.0	0.00	2.57	0.00%	100.0%	0.0	58.0	
W2070	Deciduous Forest	B	55.0	0.00	2.57	0.00%	100.0%	0.0	58.0	
W2070	Deciduous Forest	B	55.0	0.00	2.57	0.00%	100.0%	0.0	58.0	
W2070	Deciduous Forest	D	77.0	0.00	2.57	0.00%	100.0%	0.0	58.0	
W2070	Evergreen Forest	C	70.0	0.00	2.57	0.00%	100.0%	0.0	58.0	
W2070	Evergreen Forest	A	30.0	0.00	2.57	0.00%	100.0%	0.0	58.0	
W2070	Evergreen Forest	C	70.0	0.00	2.57	0.00%	100.0%	0.0	58.0	
W2070	Evergreen Forest	B	55.0	0.00	2.57	0.00%	100.0%	0.0	58.0	
W2070	Evergreen Forest	C	70.0	0.00	2.57	0.00%	100.0%	0.0	58.0	
W2070	Evergreen Forest	D	77.0	0.00	2.57	0.00%	100.0%	0.0	58.1	
W2070	Evergreen Forest	A	30.0	0.00	2.57	0.02%	100.0%	0.0	58.1	
W2070	Evergreen Forest	B	55.0	0.00	2.57	0.02%	100.0%	0.0	58.1	
W2070	Evergreen Forest	A	30.0	0.00	2.57	0.01%	100.0%	0.0	58.1	
W2070	Evergreen Forest	D	77.0	0.00	2.57	0.01%	100.0%	0.0	58.1	
W2070	Evergreen Forest	B	55.0	0.00	2.57	0.01%	100.0%	0.0	58.1	
W2070	Evergreen Forest	D	77.0	0.00	2.57	0.01%	100.0%	0.0	58.1	
W2070	Shrub/Scrub	C	65.0	0.00	2.57	0.00%	100.0%	0.0	58.1	
W2070	Shrub/Scrub	A	30.0	0.00	2.57	0.00%	100.0%	0.0	58.1	
W2070	Shrub/Scrub	C	65.0	0.00	2.57	0.00%	100.0%	0.0	58.1	
W2070	Shrub/Scrub	B	48.0	0.00	2.57	0.00%	100.0%	0.0	58.1	
W2070	Shrub/Scrub	C	65.0	0.00	2.57	0.00%	100.0%	0.0	58.1	
W2070	Shrub/Scrub	D	73.0	0.00	2.57	0.00%	100.0%	0.0	58.1	
W2070	Shrub/Scrub	B	48.0	0.00	2.57	0.00%	100.0%	0.0	58.1	
W2070	Shrub/Scrub	D	73.0	0.00	2.57	0.00%	100.0%	0.0	58.1	**58.1**
W2100	Deciduous Forest	A	30.0	0.01	1.80	0.29%	0.3%	0.1	0.1	
W2100	Deciduous Forest	B	55.0	0.04	1.80	2.08%	2.4%	1.1	1.2	
W2100	Evergreen Forest	C	70.0	0.07	1.80	4.10%	6.5%	2.9	4.1	
W2100	Evergreen Forest	A	30.0	0.05	1.80	2.91%	9.4%	0.9	5.0	
W2100	Evergreen Forest	B	55.0	1.30	1.80	72.05%	81.4%	39.6	44.6	
W2100	Shrub/Scrub	C	65.0	0.01	1.80	0.52%	82.0%	0.3	44.9	
W2100	Shrub/Scrub	A	30.0	0.02	1.80	1.36%	83.3%	0.4	45.3	
W2100	Shrub/Scrub	B	48.0	0.29	1.80	16.01%	99.3%	7.7	53.0	
W2100	Grassland/Herbaceous	B	62.0	0.01	1.80	0.68%	100.0%	0.4	53.5	**53.5**
W2110	Deciduous Forest	A	30.0	0.04	2.00	2.19%	2.2%	0.7	0.7	
W2110	Deciduous Forest	B	55.0	0.04	2.00	2.03%	4.2%	1.1	1.8	
W2110	Evergreen Forest	C	70.0	0.09	2.00	4.30%	8.5%	3.0	4.8	
W2110	Evergreen Forest	A	30.0	0.25	2.00	12.40%	20.9%	3.7	8.5	
W2110	Evergreen Forest	B	55.0	1.37	2.00	68.56%	89.5%	37.7	46.2	
W2110	Shrub/Scrub	C	65.0	0.01	2.00	0.59%	90.1%	0.4	46.6	
W2110	Shrub/Scrub	A	30.0	0.06	2.00	2.79%	92.9%	0.8	47.4	
W2110	Shrub/Scrub	B	48.0	0.13	2.00	6.71%	99.6%	3.2	50.7	
W2110	Herbaceuous	B	62.0	0.01	2.00	0.41%	100.0%	0.3	50.9	**50.9**
W2130	Deciduous Forest	B	55.0	0.02	1.16	2.04%	2.0%	1.1	1.1	
W2130	Evergreen Forest	C	70.0	0.01	1.16	0.58%	2.6%	0.4	1.5	
W2130	Evergreen Forest	B	55.0	0.90	1.16	77.82%	80.4%	42.8	44.3	
W2130	Shrub/Scrub	B	48.0	0.19	1.16	16.03%	96.5%	7.7	52.0	
W2130	Grassland/Herbaceous	B	62.0	0.04	1.16	3.52%	100.0%	2.2	54.2	**54.2**
W2220	Deciduous Forest	C	70.0	0.00	0.75	0.07%	0.1%	0.1	0.1	
W2220	Deciduous Forest	B	55.0	0.01	0.75	1.74%	1.8%	1.0	1.0	
W2220	Evergreen Forest	C	70.0	0.11	0.75	14.17%	16.0%	9.9	10.9	
W2220	Evergreen Forest	B	55.0	0.56	0.75	74.40%	90.4%	40.9	51.8	
W2220	Shrub/Scrub	C	65.0	0.00	0.75	0.00%	90.4%	0.0	51.8	
W2220	Shrub/Scrub	B	48.0	0.07	0.75	9.55%	99.9%	4.6	56.4	
W2220	Grassland/Herbaceous	B	62.0	0.00	0.75	0.07%	100.0%	0.0	56.5	**56.5**
W2240	Deciduous Forest	B	55.0	0.11	2.70	4.02%	4.0%	2.2	2.2	
W2240	Evergreen Forest	C	70.0	0.11	2.70	4.18%	8.2%	2.9	5.1	
W2240	Evergreen Forest	B	55.0	2.00	2.70	74.19%	82.4%	40.8	45.9	
W2240	Shrub/Scrub	C	65.0	0.02	2.70	0.65%	83.0%	0.4	46.4	
W2240	Shrub/Scrub	B	48.0	0.43	2.70	15.80%	98.8%	7.6	53.9	
W2240	Grassland/Herbaceous	B	62.0	0.03	2.70	1.17%	100.0%	0.7	54.7	**54.7**
W2280	Deciduous Forest	C	70.0	0.01	1.22	0.56%	0.6%	0.4	0.4	
W2280	Deciduous Forest	B	55.0	0.04	1.22	3.36%	3.9%	1.8	2.2	
W2280	Evergreen Forest	C	70.0	0.31	1.22	25.12%	29.0%	17.6	19.8	
W2280	Evergreen Forest	B	55.0	0.81	1.22	66.49%	95.5%	36.6	56.4	

BASIN	LAND USE CATEGORY	SOIL MAP UNIT #	SUBREGION CN	SUBREGION AREA (mi^2)	SUBBASIN AREA (mi^2)	PERCENT OF SUBBASIN	CUMULATIVE PERCENT	AREA-WEIGHTED CN	CUMULATIVE CN	COMPOSITE CN
W2280	Shrub/Scrub	C	65.0	0.02	1.22	1.28%	96.8%	0.8	57.2	
W2280	Shrub/Scrub	B	48.0	0.04	1.22	3.19%	100.0%	1.5	58.8	**58.8**
W2320	Deciduous Forest	B	55.0	0.02	2.74	0.61%	0.6%	0.3	0.3	
W2320	Evergreen Forest	C	70.0	0.00	2.74	0.10%	0.7%	0.1	0.4	
W2320	Evergreen Forest	B	55.0	2.49	2.74	91.00%	91.7%	50.1	50.4	
W2320	Evergreen Forest	D	77.0	0.00	2.74	0.12%	91.8%	0.1	50.5	
W2320	Shrub/Scrub	B	48.0	0.17	2.74	6.38%	98.2%	3.1	53.6	
W2320	Shrub/Scrub	D	73.0	0.00	2.74	0.17%	98.4%	0.1	53.7	
W2320	Grassland/Herbaceous	B	62.0	0.04	2.74	1.52%	99.9%	0.9	54.7	
W2320	Grassland/Herbaceous	D	85.0	0.00	2.74	0.11%	100.0%	0.1	54.8	**54.8**
W2340	Open Water	B	98.0	0.02	1.65	1.14%	1.1%	1.1	1.1	
W2340	Deciduous Forest	B	55.0	0.02	1.65	1.09%	2.2%	0.6	1.7	
W2340	Evergreen Forest	C	70.0	0.02	1.65	1.18%	3.4%	0.8	2.5	
W2340	Evergreen Forest	B	55.0	1.34	1.65	81.04%	84.5%	44.6	47.1	
W2340	Mixed Forest	B	55.0	0.00	1.65	0.11%	84.6%	0.1	47.2	
W2340	Shrub/Scrub	C	65.0	0.00	1.65	0.01%	84.6%	0.0	47.2	
W2340	Shrub/Scrub	B	48.0	0.25	1.65	14.86%	99.4%	7.1	54.3	
W2340	Grassland/Herbaceous	B	62.0	0.01	1.65	0.32%	99.7%	0.2	54.5	
W2340	Woody Wetlands	B	78.0	0.00	1.65	0.25%	100.0%	0.2	54.7	**54.7**
W2350	Deciduous Forest	B	55.0	0.01	2.28	0.52%	0.5%	0.3	0.3	
W2350	Evergreen Forest	C	70.0	0.21	2.28	9.16%	9.7%	6.4	6.7	
W2350	Evergreen Forest	B	55.0	1.85	2.28	81.29%	91.0%	44.7	51.4	
W2350	Shrub/Scrub	C	65.0	0.00	2.28	0.01%	91.0%	0.0	51.4	
W2350	Shrub/Scrub	B	48.0	0.19	2.28	8.27%	99.3%	4.0	55.4	
W2350	Grassland/Herbaceous	B	62.0	0.02	2.28	0.75%	100.0%	0.5	55.8	**55.8**
W2450	Deciduous Forest	C	70.0	0.00	1.24	0.22%	0.2%	0.2	0.2	
W2450	Deciduous Forest	B	55.0	0.01	1.24	0.67%	0.9%	0.4	0.5	
W2450	Evergreen Forest	C	70.0	0.36	1.24	29.11%	30.0%	20.4	20.9	
W2450	Evergreen Forest	B	55.0	0.79	1.24	63.76%	93.8%	35.1	56.0	
W2450	Shrub/Scrub	B	48.0	0.08	1.24	6.23%	100.0%	3.0	59.0	**59.0**
W2460	Deciduous Forest	C	70.0	0.00	1.14	0.43%	0.4%	0.3	0.3	
W2460	Evergreen Forest	C	70.0	0.52	1.14	46.12%	46.6%	32.3	32.6	
W2460	Evergreen Forest	B	55.0	0.56	1.14	49.21%	95.8%	27.1	59.7	
W2460	Mixed Forest	C	70.0	0.00	1.14	0.27%	96.0%	0.2	59.8	
W2460	Shrub/Scrub	C	65.0	0.01	1.14	0.84%	96.9%	0.5	60.4	
W2460	Shrub/Scrub	B	48.0	0.04	1.14	3.12%	100.0%	1.5	61.9	**61.9**
W2470	Deciduous Forest	B	55.0	0.00	0.28	0.63%	0.6%	0.3	0.3	
W2470	Evergreen Forest	C	70.0	0.00	0.28	1.25%	1.9%	0.9	1.2	
W2470	Evergreen Forest	B	55.0	0.22	0.28	80.71%	82.6%	44.4	45.6	
W2470	Shrub/Scrub	B	48.0	0.04	0.28	15.78%	98.4%	7.6	53.2	
W2470	Grassland/Herbaceous	B	62.0	0.00	0.28	1.63%	100.0%	1.0	54.2	**54.2**
W2490	Evergreen Forest	C	70.0	0.12	0.84	14.72%	14.7%	10.3	10.3	
W2490	Evergreen Forest	B	55.0	0.67	0.84	78.90%	93.6%	43.4	53.7	
W2490	Shrub/Scrub	C	65.0	0.00	0.84	0.09%	93.7%	0.1	53.8	
W2490	Shrub/Scrub	B	48.0	0.05	0.84	6.11%	99.8%	2.9	56.7	
W2490	Grassland/Herbaceous	B	62.0	0.00	0.84	0.18%	100.0%	0.1	56.8	**56.8**
W2500	Evergreen Forest	C	70.0	0.14	0.41	34.80%	34.8%	24.4	24.4	
W2500	Evergreen Forest	B	55.0	0.24	0.41	58.98%	93.8%	32.4	56.8	
W2500	Shrub/Scrub	C	65.0	0.01	0.41	2.97%	96.7%	1.9	58.7	
W2500	Shrub/Scrub	B	48.0	0.01	0.41	3.25%	100.0%	1.6	60.3	**60.3**
W2510	Deciduous Forest	C	70.0	0.00	1.59	0.02%	0.0%	0.0	0.0	
W2510	Deciduous Forest	B	55.0	0.03	1.59	1.69%	1.7%	0.9	0.9	
W2510	Evergreen Forest	C	70.0	0.55	1.59	34.67%	36.4%	24.3	25.2	
W2510	Evergreen Forest	B	55.0	0.69	1.59	43.57%	79.9%	24.0	49.2	
W2510	Evergreen Forest	D	77.0	0.16	1.59	9.99%	89.9%	7.7	56.9	
W2510	Shrub/Scrub	C	65.0	0.01	1.59	0.76%	90.7%	0.5	57.4	
W2510	Shrub/Scrub	B	48.0	0.06	1.59	3.88%	94.6%	1.9	59.2	
W2510	Shrub/Scrub	D	73.0	0.03	1.59	1.99%	96.6%	1.5	60.7	
W2510	Grassland/Herbaceous	C	74.0	0.00	1.59	0.16%	96.7%	0.1	60.8	
W2510	Grassland/Herbaceous	B	62.0	0.00	1.59	0.16%	96.9%	0.1	60.9	
W2510	Grassland/Herbaceous	D	85.0	0.05	1.59	2.99%	99.9%	2.5	63.4	
W2510	Woody Wetlands	C	78.0	0.00	1.59	0.13%	100.0%	0.1	63.5	**63.5**
W2540	Deciduous Forest	C	70.0	0.00	1.52	0.09%	0.1%	0.1	0.1	
W2540	Deciduous Forest	B	55.0	0.01	1.52	0.71%	0.8%	0.4	0.5	
W2540	Evergreen Forest	C	70.0	0.08	1.52	5.42%	6.2%	3.8	4.2	
W2540	Evergreen Forest	B	55.0	1.30	1.52	85.46%	91.7%	47.0	51.2	
W2540	Mixed Forest	B	55.0	0.01	1.52	0.48%	92.1%	0.3	51.5	
W2540	Shrub/Scrub	C	65.0	0.00	1.52	0.15%	92.3%	0.1	51.6	
W2540	Shrub/Scrub	B	48.0	0.10	1.52	6.65%	99.0%	3.2	54.8	
W2540	Grassland/Herbaceous	B	62.0	0.02	1.52	1.05%	100.0%	0.6	55.4	**55.4**
W2560	Deciduous Forest	C	70.0	0.01	1.96	0.60%	0.6%	0.4	0.4	
W2560	Deciduous Forest	D	77.0	0.00	1.96	0.00%	0.6%	0.0	0.4	
W2560	Evergreen Forest	C	70.0	0.52	1.96	26.48%	27.1%	18.5	19.0	
W2560	Evergreen Forest	B	55.0	0.75	1.96	37.99%	65.1%	20.9	39.9	
W2560	Evergreen Forest	D	77.0	0.38	1.96	19.48%	84.6%	15.0	54.9	
W2560	Shrub/Scrub	C	65.0	0.03	1.96	1.28%	85.8%	0.8	55.7	
W2560	Shrub/Scrub	B	48.0	0.03	1.96	1.38%	87.2%	0.7	56.4	
W2560	Shrub/Scrub	D	73.0	0.18	1.96	9.15%	96.4%	6.7	63.0	
W2560	Grassland/Herbaceous	C	74.0	0.00	1.96	0.13%	96.5%	0.1	63.1	
W2560	Grassland/Herbaceous	B	62.0	0.01	1.96	0.49%	97.0%	0.3	63.4	
W2560	Grassland/Herbaceous	D	85.0	0.06	1.96	2.91%	99.9%	2.5	65.9	
W2560	Woody Wetlands	C	78.0	0.00	1.96	0.09%	100.0%	0.1	66.0	**66.0**
W2570	Deciduous Forest	C	70.0	0.01	3.00	0.19%	0.2%	0.1	0.1	
W2570	Evergreen Forest	C	70.0	0.94	3.00	31.36%	31.5%	22.0	22.1	
W2570	Evergreen Forest	B	55.0	0.47	3.00	15.69%	47.2%	8.6	30.7	
W2570	Evergreen Forest	D	77.0	1.25	3.00	41.53%	88.8%	32.0	62.7	
W2570	Shrub/Scrub	C	65.0	0.00	3.00	0.09%	88.9%	0.1	62.7	
W2570	Shrub/Scrub	B	48.0	0.09	3.00	2.94%	91.8%	1.4	64.2	
W2570	Shrub/Scrub	D	73.0	0.15	3.00	4.97%	96.8%	3.6	67.8	
W2570	Grassland/Herbaceous	C	74.0	0.00	3.00	0.06%	96.8%	0.0	67.8	
W2570	Grassland/Herbaceous	B	62.0	0.01	3.00	0.28%	97.1%	0.2	68.0	
W2570	Grassland/Herbaceous	D	85.0	0.09	3.00	2.90%	100.0%	2.5	70.5	**70.5**

APPENDIX G

LAG TIME CALCULATIONS

Basin	CN	Avg Basin Slope (%)	Longest flow path (ft)	Lag (hr)	Lag (min)	Tc (hr)	Tc (min)
W01	89.7	2.87	3899.35	0.40	23.70	0.66	39.50
W010	65.2	10.17	9193.76	0.89	53.42	1.48	89.04
W011	75.6	2.09	2836.00	0.58	34.68	0.96	57.80
W012	78.2	1.55	3234.92	0.69	41.31	1.15	68.85
W0121	65.7	9.37	12691.88	1.19	71.21	1.98	118.69
W0122	59.8	21.35	26930.96	1.67	100.06	2.78	166.76
W0123	48.7	31.86	18934.76	1.36	81.81	2.27	136.36
W0124	49.9	48.36	16358.02	0.96	57.31	1.59	95.51
W013	73.1	2.00	7847.60	1.43	85.82	2.38	143.04
W014	68.1	2.53	7344.64	1.38	82.91	2.30	138.19
W0141	74.6	1.55	6327.08	1.31	78.84	2.19	131.41
W015	77.4	2.80	1310.43	0.25	15.29	0.42	25.48
W0151	77.2	2.72	6457.14	0.93	56.04	1.56	93.40
W016	75.1	2.57	10484.12	1.50	90.21	2.51	150.34
W017	75.2	4.43	11997.05	1.27	76.20	2.12	127.00
W02	95.6	3.62	2543.29	0.19	11.45	0.32	19.08
W021	91.1	1.41	6104.21	0.76	45.86	1.27	76.44
W022	86.5	1.51	8285.67	1.13	67.73	1.88	112.89
W030	88.4	1.39	1432.89	0.27	16.09	0.45	26.82
W031	87.3	1.20	4318.94	0.73	43.72	1.21	72.86
W04	87.1	1.41	5180.61	0.78	46.95	1.30	78.25
W041	88.5	1.93	11790.73	1.22	73.48	2.04	122.46
W05	89.2	1.47	2043.39	0.34	20.24	0.56	33.73
W06	84.4	1.52	2583.52	0.48	28.62	0.80	47.70
W07	79.6	15.09	7797.57	0.43	25.72	0.71	42.86
W08	77.4	5.62	6479.17	0.65	38.76	1.08	64.60
W09	69.7	8.98	9214.24	0.84	50.59	1.41	84.32
W2070	58.1	33.44	19619.80	1.08	64.81	1.80	108.02
W2100	53.5	39.51	11577.85	0.73	43.94	1.22	73.24
W2110	50.9	45.95	14228.46	0.85	51.24	1.42	85.40
W2130	54.2	45.21	13191.26	0.75	44.74	1.24	74.57
W2220	56.5	25.29	8544.73	0.67	39.92	1.11	66.54
W2240	54.7	38.32	13079.20	0.80	47.72	1.33	79.53
W2280	58.8	42.63	15550.24	0.78	46.86	1.30	78.10
W2320	54.8	31.44	20855.56	1.27	76.33	2.12	127.21
W2340	54.7	29.59	14413.30	0.98	58.63	1.63	97.71
W2350	55.8	47.04	17769.47	0.89	53.41	1.48	89.02
W2450	59.0	47.70	12242.93	0.61	36.40	1.01	60.66
W2460	61.9	27.39	14247.57	0.84	50.34	1.40	83.90
W2470	54.2	54.01	5100.38	0.32	19.15	0.53	31.91
W2490	56.8	49.81	10543.05	0.56	33.37	0.93	55.62
W2500	60.3	49.87	8395.23	0.42	25.45	0.71	42.42
W2510	63.5	41.55	15768.41	0.71	42.51	1.18	70.84
W2540	55.4	47.97	13968.93	0.73	44.07	1.22	73.46
W2560	66.0	52.55	17318.62	0.64	38.23	1.06	63.72
W2570	70.5	52.44	17165.38	0.56	33.73	0.94	56.21