Mathew-Bird 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, Gallatin County, Montana (**Reference 5**), RESPEC is completing a detailed floodplain study for approximately 3.8 miles of Mathew-Bird Creek within Gallatin County, Montana. The Mathew-Bird Creek study limits extend from the stream mouth to the upstream limit of approximately 3,350 feet upstream of Goldenstein Lane. The project area is displayed in **Figure 1-1**.

A Flood Insurance Study (FIS) has been completed for Gallatin County (**Reference 6**). The entire Mathew-Bird Creek study reach has been previously studied. Flood hazards are currently mapped as Zone AE with floodway. The effective flooding for Mathew-Bird Creek is shown in **Figure 1-2**.

The hydrologic analysis for Mathew-Bird 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 Mathew-Bird Creek watershed is located within the Bozeman Creek watershed (HUC 12 100200080905). The entire Mathew-Bird watershed encompasses an area of 4.0 mi^2. Mathew-Bird Creek originates in the foothills of the Northern Gallatin Range and transitions to low sloping valley. At the downstream study limit, Mathew-Bird Creek joins Bozeman Creek. Upstream of the upstream study limit, irrigation practices and roads have altered the natural drainage patterns of the upper basin. Mathew-Bird Creek begins to show channel definition at the upstream study limit and flows in a northerly direction through cultivated fields outside the City of Bozeman corporate limits. As Mathew-Bird Creek transitions from an agricultural surrounding to a landscape dominated by residential development, overbank areas remain minimally developed and contain hearty riparian vegetation. Several small check structures exist along the stream between the proximity of Sundance Drive and Graf Street. Just downstream of Kagy Boulevard, Figgins Creek enters Mathew-Bird Creek. Figgins Creek is a concurrent flood study. Downstream of Figgins Creek, the overbank areas are fully developed and a narrow band of riparian vegetation lines the stream corridor. The remainder of the reach appears altered, with limited overbank storage, and transitions between residential, light industrial, and open-space recreational areas.

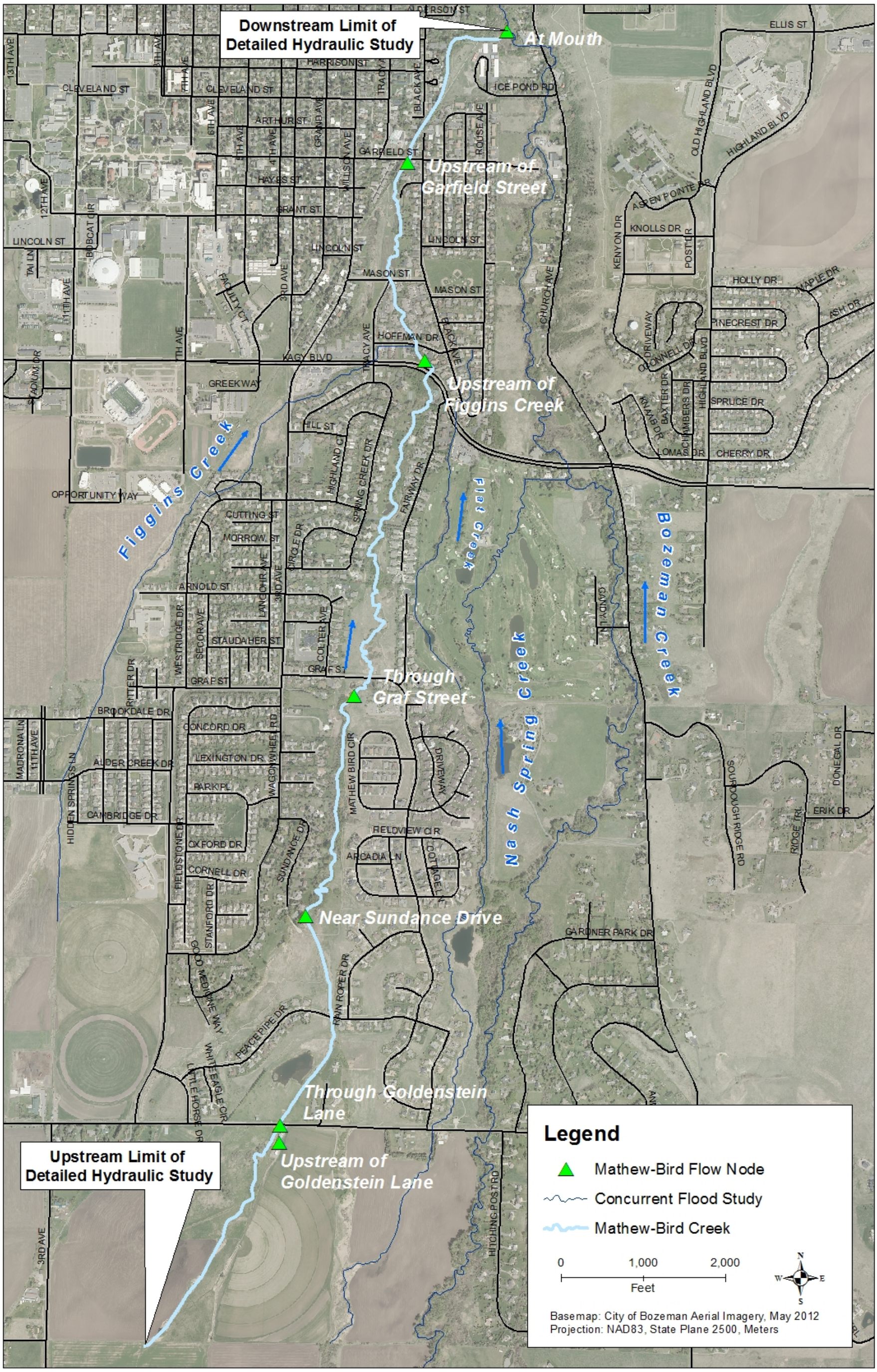

Figure 1-1. Mathew-Bird Creek Study Reach

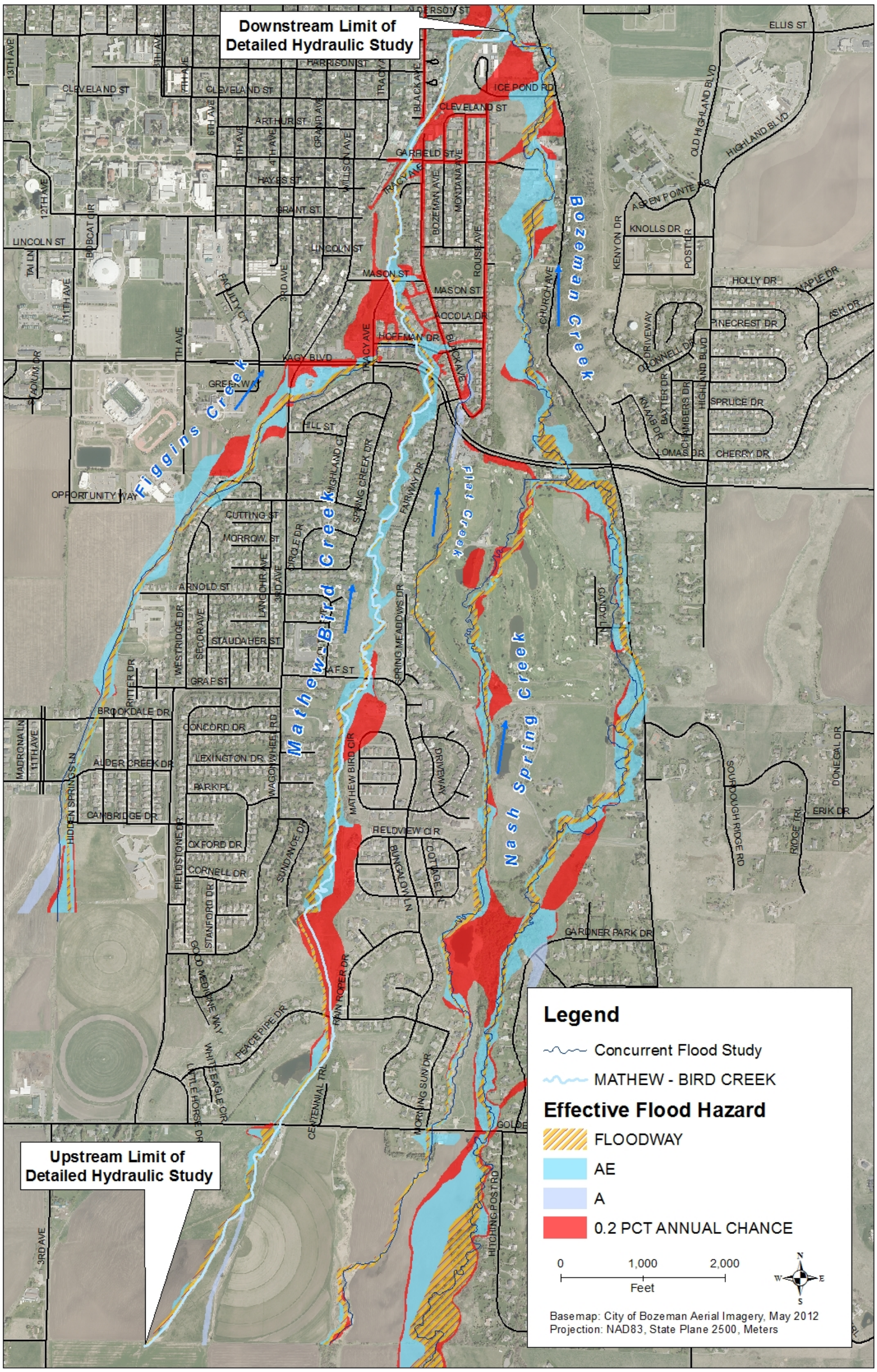

Figure 1-2. Effective flood hazard areas for Mathew-Bird Creek

1.3 Effective Hydrologic Analysis

As previously mentioned, flood hazards are currently mapped as detailed Zone AE with floodway for the entire study area of Mathew-Bird Creek. Described in the Gallatin County FIS, an original hydrologic analysis of Mathew-Bird Creek was completed in June 1979 by the U.S. Department of Agriculture, Natural Resources Conservation Service. A revised hydrologic analysis of Mathew-Bird Creek was completed by Morrison Maierle, Inc. in January 1985. The effective FIS states that peak discharges developed for Mathew-Bird Creek were computed using regression equations developed from 10 gages near the study area.

1.4 Flooding History

Notable flooding within the watershed has been recorded along Bozeman Creek in April 1893, April 1948, April 1977, 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. There is no reference as to the history of flooding along Mathew-Bird Creek within the FIS and limited information available as to flooding along the spring creeks. Local administrators and citizens state that the higher discharges associated with the spring creeks south of Bozeman are largely attributed to receiving overflowing flood discharges diverted from Bozeman Creek.

1.5 Other Studies

The City of Bozeman (the City) was consulted for previous study information for Mathew-Bird Creek. Unfortunately, the City could not provide hydrologic data pertaining to the 100-yr event for the watershed other than the FIS. 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. However, the City referred to the Montana Department of Transportation (MDT) for as-built plans of Kagy Boulevard which was constructed in the 1980s. The as-built plans of Kagy Boulevard, included as Supplemental Data, 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 Mathew-Bird Creek (referred to as Spring Creek), the 100-yr discharge is reported as 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.

2. HYDROLOGIC ANALYSES

Because no gage data is available for Mathew-Bird Creek, regional regression equations along with an HEC-HMS model were used to calculate the peak discharges. Standards and guidance were followed from the Federal Emergency Management Agency (FEMA) Knowledge and Sharing Site (KSS), (**Reference 8**) and FEMA Guidelines and Specifications, Appendix C (**Reference 7**), respectively. The study reach was reviewed along its entire length to establish flow change locations. This ensures a realistic discharge is applied to each portion of the reach since several significant portions of drainage area enter the reach along its length. These flow change locations are shown on **Figure 1-1**.

It should be noted that the basin has had a history of alterations to its natural drainage patterns primarily for irrigation purposes but also for roads. Several irrigation ditches are located throughout the basin and the stream itself has been realigned from its natural drainage. To some extent, the irrigation ditches have been incorporated into the analysis in the form of longest flow paths and routing. Two ditches, Middle Creek Ditch and Mystic Lake Ditch transfer flow to the basin from neighboring watersheds. These ditches require manual operation to divert flow from its source (Hyalite Creek and Bozeman Creek, respectively) through gates. Additionally, it is suspected that many manually operated controls regulate that flow before reaching the basin. For this analysis, it is assumed that all ditch controls are closed and flow from adjacent watersheds does not enter the basin. Additional discussion of flow alterations is provided in the **Section 3**.

2.1 Regression Analysis

Regression analysis was performed to compute flood frequency peak discharges values for specific locations along Mathew-Bird Creek. Due to Mathew-Bird Creek being comprised of both rural and urban developing environments, the regional regression analysis for Montana was utilized, as well as an urban regression weighted procedure. These analyses are described further in the following sections.

2.1.1 Regional Regression Equation Analysis

Regional regression equations were used to compute the annual peak discharge values for the Mathew-Bird 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 14**). USGS WRIR 03-4308 separates Montana into eight different regions based on topography and climatic conditions. The entire drainage area for Mathew-Bird 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. Along with each method, the Standard Error of Prediction (SEP) is provided as a reliability indicator. Smaller SEP percentages point to greater reliability of the regression equations used.

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 study reach was divided into several The basin characteristics equation for the Upper Yellowstone-Central Mountain Region requires drainage area (A) and the percentage of drainage area above elevation of 6000' (E_{6000}) as inputs. The drainage areas were delineated using 2 ft LiDAR contours (**Reference 9**) for the Mathew-Bird Creek drainage basin. Delineation of the upper reaches of the watershed beyond the LiDAR extent relied on a USGS 10m Digital Elevation Model topography. Drainage area delineations for the Mathew-Bird Creek watershed are shown in **Figure 2-1.** The calculated basin parameters are shown in **Table 2-1** along with the range of values utilized by USGS for development of the regression equations.

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

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 Mouth	3.96	0.91	6	9.5
Upstream of Garfield Street	3.80	0.94	7.5	12
Upstream of Figgins Creek	2.74	1.31	10	13
Through Graf Street	2.58	1.39	8	13
Near Sundance Drive	2.36	1.52	6*	12.5*
Through Goldenstein Lane	2.19	1.63	4	12

**average from surrounding measurements used*

Regression equations for basin characteristics, active-channel width and bankfull width were calculated for Mathew-Bird Creek. Regression estimates generated by active-channel width, and bankfull width were calculated but not presented. As mentioned, Mathew-Bird Creek has been manipulated for development purposes. In many locations throughout the study reach the channel contains rock lining which alters the sediment transport regime and disrupts natural channel morphology.

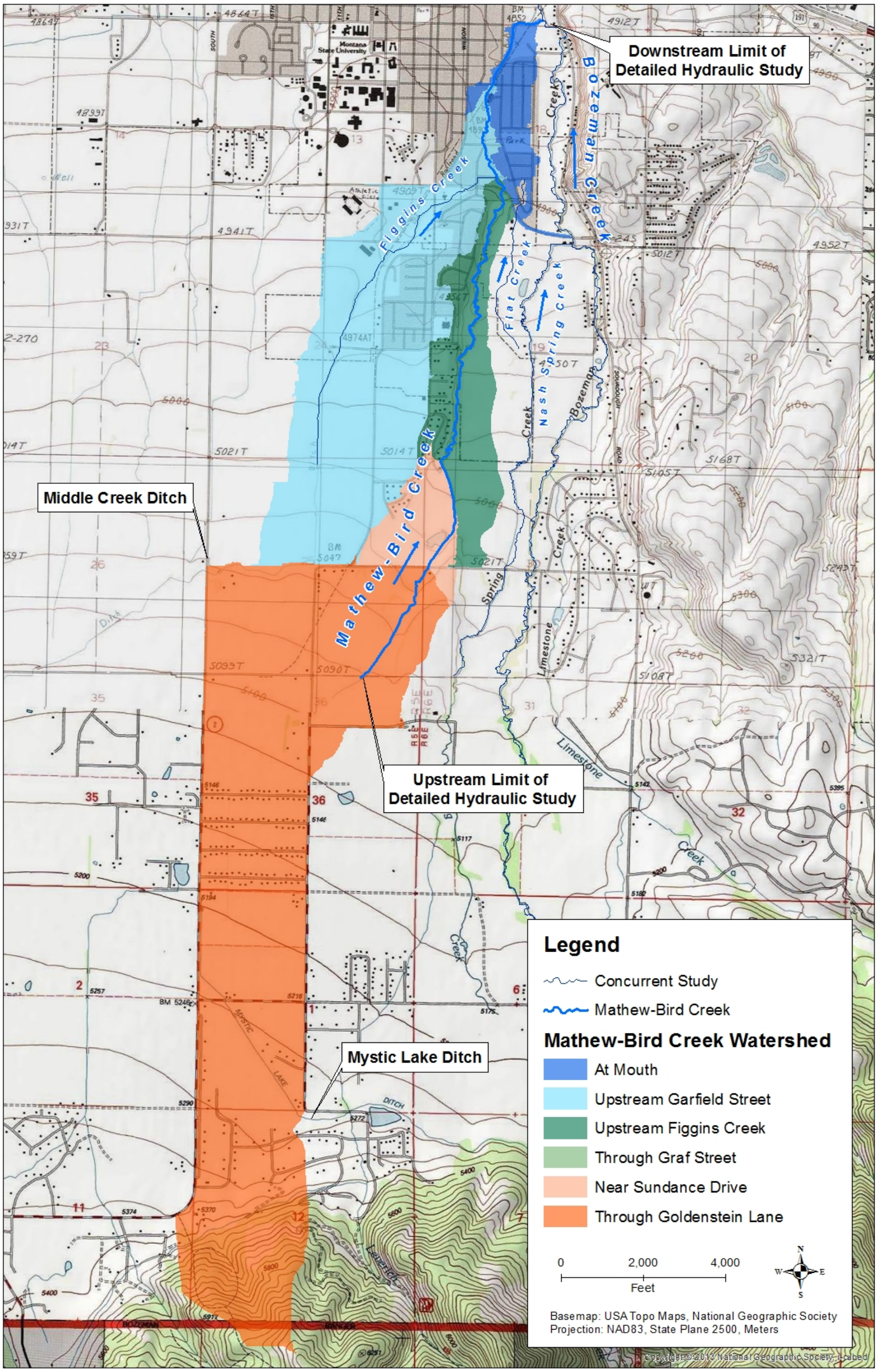

Figure 2-1. Mathew-Bird Creek basin characteristics regression watershed delineations

It is suspected that these alterations introduce uncertainty to the methods' applicability. This is reflected in the field measurements shown in **Table 2-1** where the upstream portion of the reach shows widths that logically increase in the downstream direction until the stream enters the urbanized corridor where reduced widths were observed. Regardless, various weighted combinations of the three regression methods (basin characteristics, active-channel width, bankfull width) were computed. All calculations were performed using the web-based USGS Flood Discharge at Ungaged Sites in Montana program. The program utilizes the equations presented in WRIR 03-4308. Results of the regression analyses are included in Section 3 and the output data from the USGS web-based program is included in **Appendix A**.

2.1.2 Urban Weighted Regression

As previously mentioned, the Mathew-Bird Creek watershed is comprised of rural and urban environments. Since the regression analysis detailed in USGS WRIR 03-4308 is predominately based off of rural datasets, the regression methods detailed in *Flood Characteristics of Urban Watersheds in the United States USGS Water-Supply Paper 2207* (USGS WSP 2207) (**Reference 16**) were also used. The three parameter equations presented in USGS WSP 2207 provide methods for applying a basin development factor (BDF) to the rural regression estimates in order to account for the urbanization present within the watershed. Four components determine the BDF and if those components are "prevalent" (greater than 50% occurrence) in the watershed, the component gets a score of one (1). Four components are rated for each 1/3 of the basin and are then summed to determine the BDF. The BDF was estimated for five of the six locations listed in **Table 2-1**. For Mathew-Bird Creek at Mouth and Upstream of Garfield Street, the BDF was estimated to be four (4). This rating is due to the Mathew-Bird Creek channel having improvements and the watershed containing storm drains for more than 50% of the bottom 1/3 of the watershed. These factors were not prevalent in the other 2/3 of the watershed. The presence of curb and gutter was suspected to be prevalent in the bottom 2/3 of the watershed, hence the BDF score of four (4). The further upstream flow change locations (Through Graf Street and Near Sundance) do not contain these developments for greater than 50% of its area so the BDF for these basins is zero. The BDF used for Mathew-Bird Upstream of Figgins Creek was three (3). The watershed above the Through Goldenstein Lane flow change location is not suitable for this methodology because it does not contain 15% of its area covered by commercial, industrial, or residential developments. Results of the regression analyses are included in **Section 3** of this report.

2.2 HEC-HMS Rainfall-Runoff Analysis

The Mathew-Bird 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. The subbasins utilized in the hydrologic modeling of Mathew-Bird Creek are shown in **Figure 2-2**.

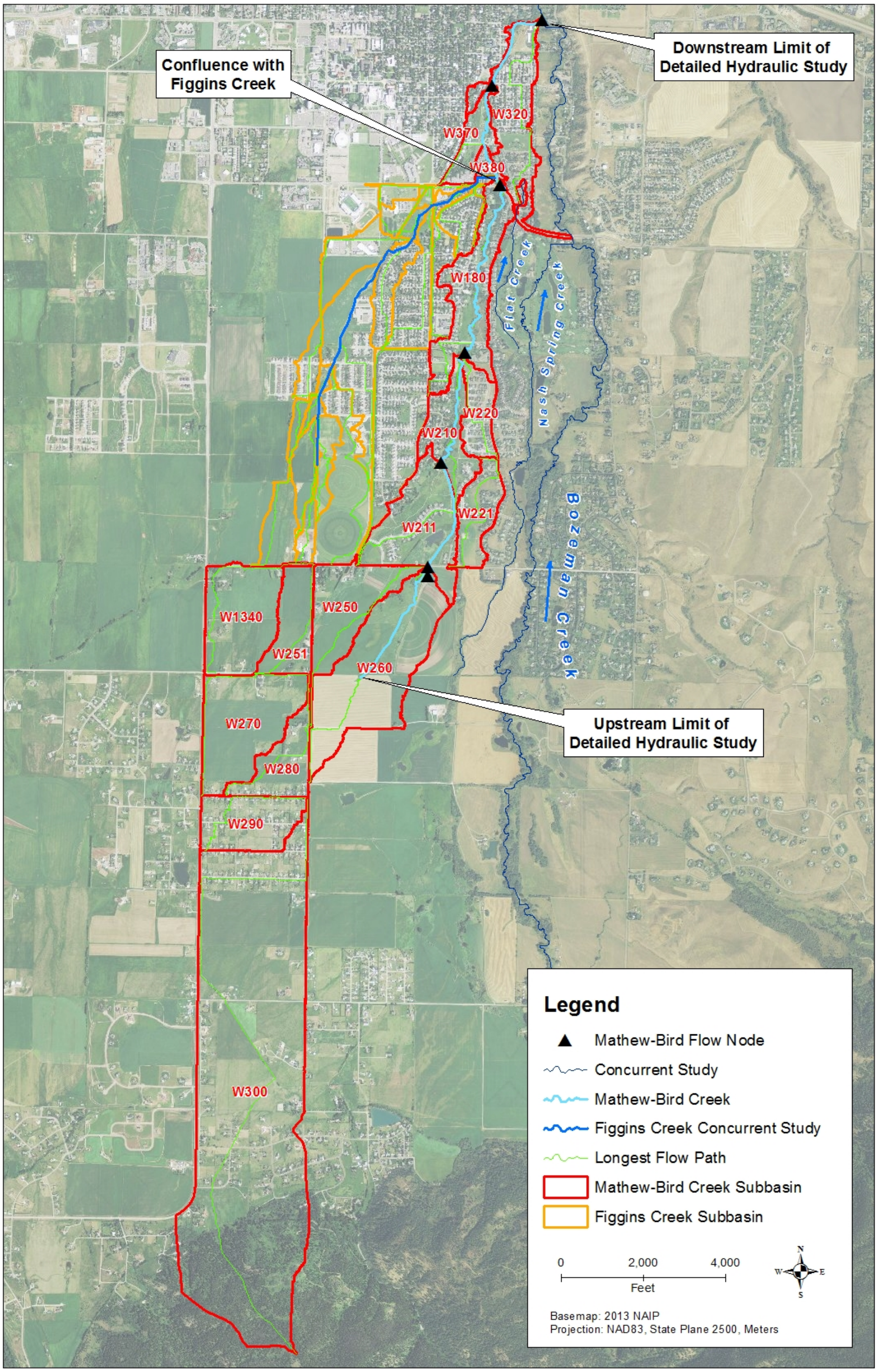

Figure 2-2. Subbasins and longest flow paths utilized for the hydrologic model

As mentioned, Figgins Creek enters Mathew-Bird Creek just downstream of Kagy Boulevard and is a concurrent flood study. The Figgins Creek HEC-HMS model was embedded into the HEC-HMS model of Mathew-Bird Creek. For the Figgins Creek basins within the Mathew-Bird Creek HEC-HMS model, all input parameters described below are identical to the Figgins Creek HEC-HMS model to ensure consistency between the concurrent flood studies. The Figgins Creek hydrologic analysis report (**Reference 15**) contains detailed information regarding the Figgins Creek portion of the Mathew-Bird Creek analysis. The Figgins Creek subbasins within the Mathew-Bird Creek HEC-HMS model are identified by an "F" prefix to the subbasin name followed by a "-1" suffix. For example, the Figgins Creek subbasin "W100" becomes "FW100-1". This modification to the naming system allows quick identification of Figgins Creek basins within the Mathew-Bird Creek HEC-HMS model. Refer to the Figgins Creek hydrologic analysis report for the basin parameters and calculations utilized for the Figgins Creek subbasins within the Mathew-Bird Creek watershed since those values are not presented.

The meteorological model for Mathew-Bird 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 was the Curve Number Method described in the National Engineering Handbook (**Reference 12**). The Muskingum-Cunge routing method was used to route the hydrograph through the watershed.

2.2.1 Precipitation

Design storms used in the hydrologic analysis of Mathew-Bird 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 10)** 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 1**). 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 2-2**. All pertinent data used to determine the depths are included in **Appendix B**.

Table 2-2. 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 (the City) *Design Standards and Specifications Policy* (**Reference 3).** 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. Soils coverage for the Mathew-Bird Creek watershed was obtained in Soil Survey Geographic (SSURGO) format from the Natural Resources Conservation Service (NRCS) Geospatial Data Gateway (**Reference 11**). The hydrologic soil groups present within the Mathew-Bird Creek watershed are displayed in **Figure 2-3**. Land use data was also obtained from the NRCS Geospatial Data Gateway as well as the City (**Reference 4***)*. The land use classifications present within the Mathew-Bird Creek watershed are displayed in **Figure 2-4**. 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 13**) 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.

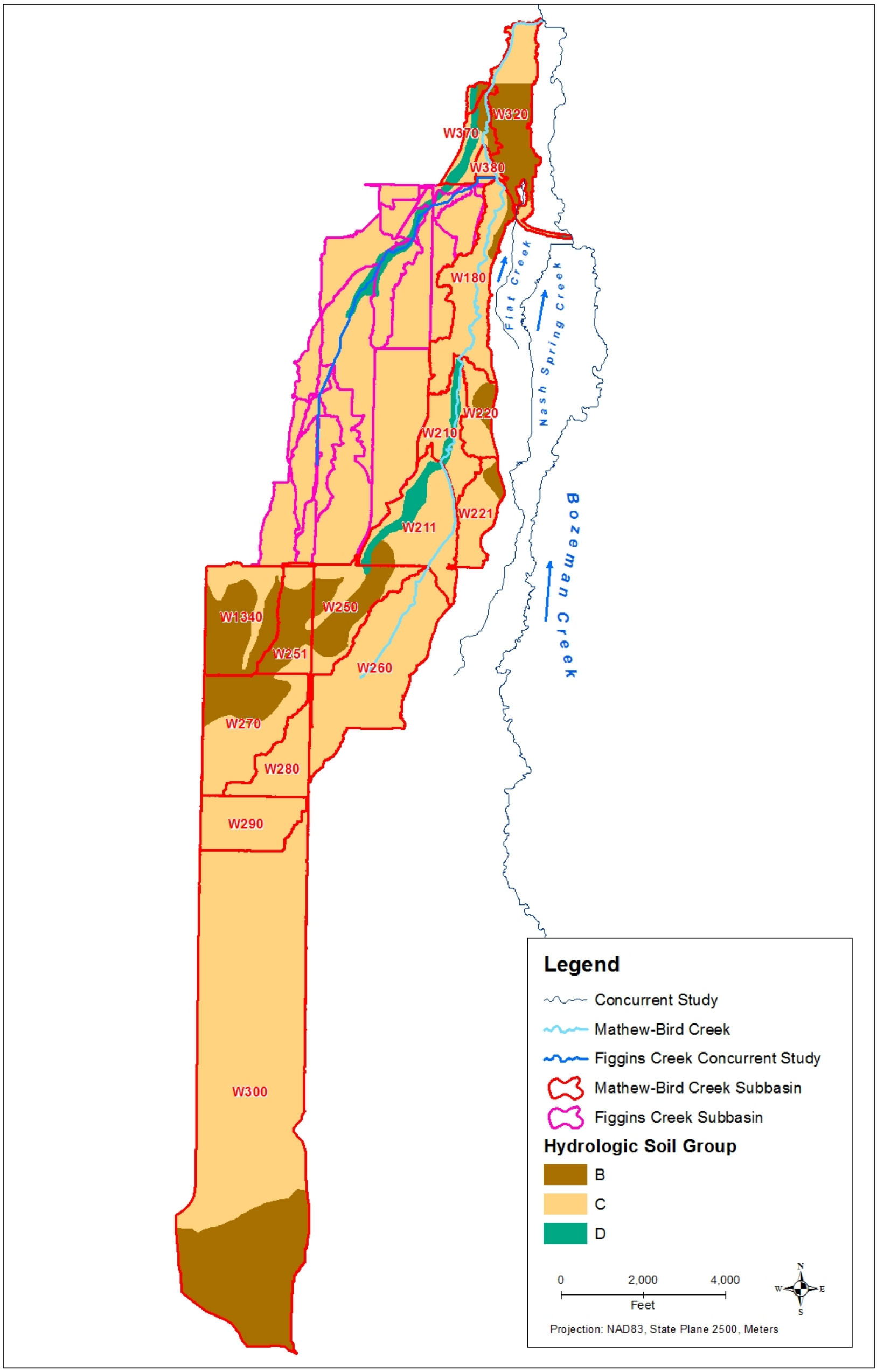

Figure 2-3. Hydrologic soil groups present within the Mathew-Bird Creek watershed

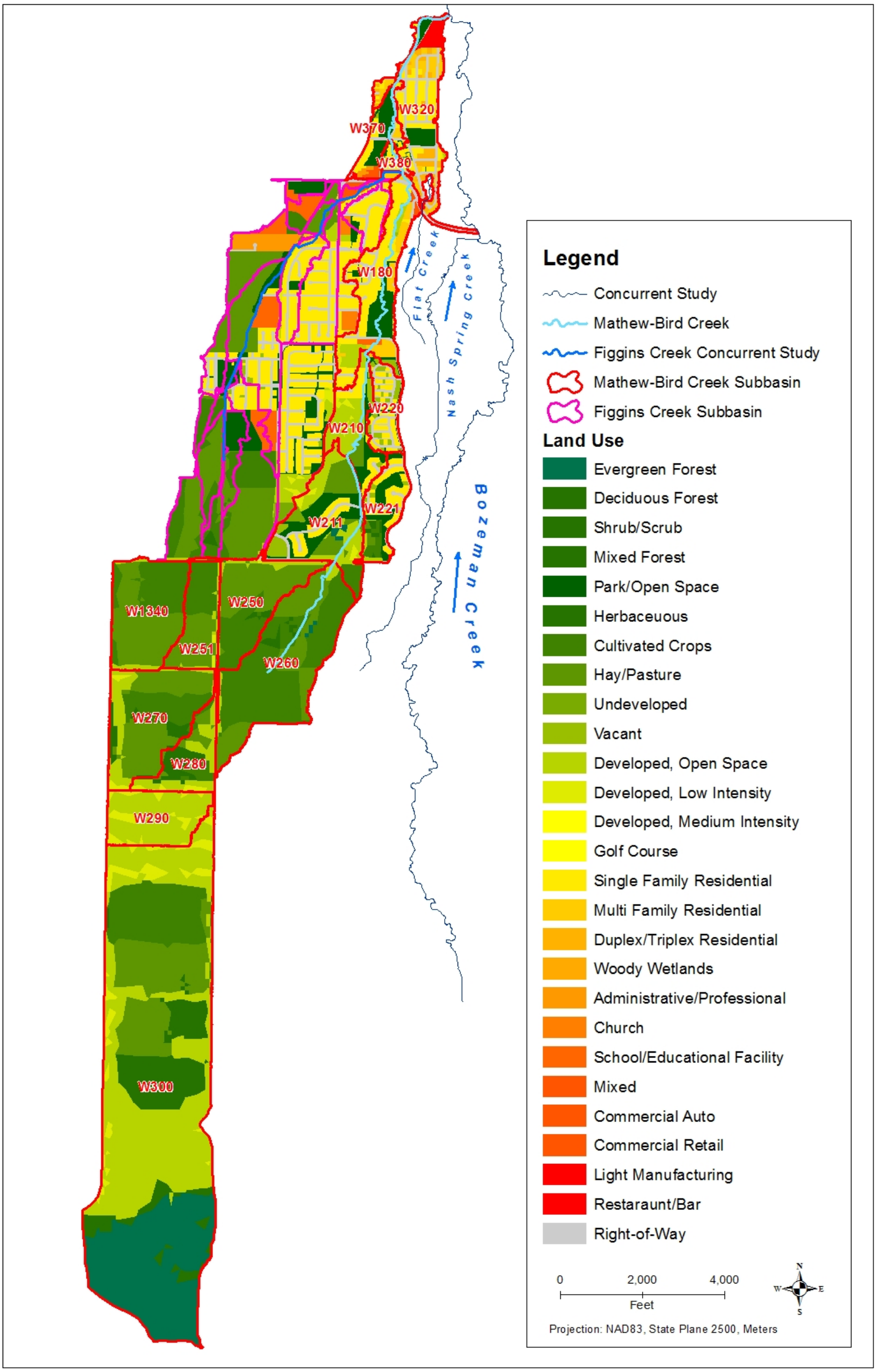

Figure 2-4. Descriptions of land uses present within the Mathew-Bird Creek watershed

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 C**.

The cumulative loss rate of each subbasin was determined by calculating an areal weighted-average curve number value. This final weighted-average curve numbers for the subbasins of Mathew-Bird Creek are shown in **Table 2-3** along with drainage areas for the various subbasins. Calculations for the curve number method are included in **Appendix D**.

Table 2-3. Summary of hydrologic parameters for each basin*

HMS Basin	Area (mi^2)	Composite CN	Hydraulic Length (ft)	Average Watershed Land Slope (%)	Lag (min)	t_c (hr)
W1340	0.1631	68.5	5,894.7	1.5	90.1	2.5
W180	0.1603	83.7	9,031.1	3.2	54.9	1.5
W210	0.0879	78.8	4,931.7	3.4	38.7	1.1
W211	0.1657	79.0	4,910.7	2.5	44.8	1.2
W220	0.0553	87.7	3,487.6	1.4	33.7	0.9
W221	0.0723	80.2	4,784.3	2.0	46.9	1.3
W250	0.1381	70.1	6,524.5	1.5	94.5	2.6
W251	0.0866	68.9	3,945.7	1.3	68.8	1.9
W260	0.2779	78.2	7,631.4	1.7	79.6	2.2
W270	0.1926	71.1	5,869.6	1.6	79.9	2.2
W280	0.0845	75.0	5,072.1	1.9	59.5	1.7
W290	0.1105	75.1	4,292.9	2.0	50.7	1.4
W300	1.1410	69.1	17,839.3	9.9	83.3	2.3
W320	0.1510	84.7	6,705.4	1.4	63.5	1.8
W370	0.0493	81.5	3,569.1	1.6	40.3	1.1
W380	0.0114	84.5	1,382.9	1.7	16.3	0.5

**Figgins Creek subbasins within Mathew-Bird Creek watershed not shown, refer to Figgins Creek hydrologic analysis report.*

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 (shown graphically in **Figure 2-2)**; 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 from a USGS 10-m DEM dataset. 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. The slope tool within ArcGIS calculates slope for each cell of the DEM, for which an average is then obtained. It was discovered that average basin slope obtained through the ArcGIS slope tool compared well to the same parameter obtained by measuring contour lines.

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 **Table 2-3**. Supplemental information and calculations are provided in **Appendix E**.

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. One routing reach was delineated using ArcGIS 10.1. The eight-point channel cross section, length and slope was created for the reach utilizing the LiDAR topography. 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 2**) provided tables of roughness coefficients for different surfaces. Assigned Manning's values throughout the simulated reach was 0.04 for the channel to represent a meandering channel with stones and objects of variable form roughness. A Manning's value of 0.08 was assigned to the overbank portion of the section to describe the dense vegetation observed for this reach.

Once all hydrologic parameters are obtained and entered into the HEC-HMS model, the program calculates hydrographs for each element in the model. Those results are provided in Section 3.

3. HYDROLOGIC ANALYSES RESULTS AND DISCUSSION

3.1 Summary of Discharges

The effective discharges for Mathew-Bird Creek are shown in **Table 3-1**.

Table 3-1. Effective discharges for Mathew-Bird 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)
Above Kagy Boulevard	2.5	73	*N/A*	143	190	276
At Graf Street	2.5	71	*N/A*	140	186	271
At Goldenstein Lane	2.1	65	*N/A*	129	173	251
Approximately 0.4 miles upstream from Goldenstein Lane	1.7	57	*N/A*	115	155	225

Very little specific information pertaining to the hydrologic methods and results is provided in the effective FIS. The flow change locations utilized in the effective study correspond reasonably well to the proposed flow change locations of the present study. This is emphasized upon comparison of **Table 3-1** to **Table 2-1**, where the drainage areas for similar locations (At Graf Street and Through Graf Street, At Goldenstein Lane and Through Goldenstein Lane) are within 0.1 square miles. It is evident that the effective study did not calculate flow at the most downstream extent of the study reach since their maximum drainage area utilized was 2.5 mi^2 whereas the present study utilized the drainage area at the mouth of 3.96 mi^2. The Summary of Discharges Table in the FIS report contains a footnote for Mathew-Bird Creek stating, "Peak discharges larger than computed by Regression Equations due to the transfer of flows to each basin by uncontrolled irrigation and road ditches." This suggests that the inter-basin transfer of flow through irrigation ditches is significant compared to their regional regression equation estimates. Unfortunately, no documentation of their analysis was available for review during this study. Annotated on **Figure 2-1**, is the Middle Creek Ditch and the Mystic Lake Ditch which are speculated to contribute flow to the basin. These ditches were neglected from the analysis since their ability to contribute flow relies on manual operation of flow control structures.

Results of the USGS Basin Characteristics regression equations, the USGS Urban Regression weighting procedure, and the HEC-HMS model are summarized in **Table 3-2** through **Table 3-7** and shown graphically on **Figure 3-1** through **Figure 3-6**. The results shown are for identical flow node locations for the three methods compared. As mentioned, the channel width regression equations were computed (**Appendix A**) but not presented due to anthropogenic alterations to the channel introducing uncertainty to the methods' applicability.

Table 3-2. Resultant discharges for Mathew-Bird Creek at Mouth

Method	Discharge (cfs)				
	10%-Annual-Chance	4%-Annual-Chance	2%-Annual-Chance	1%-Annual-Chance	0.2%-Annual-Chance
2004 USGS Regional Regression Equations - Basin Characteristics	113	206	299	415	794
1983 Urban Regression - Basin Characteristics	225	359	495	657	1150
HEC-HMS (HEC-HMS Element Mouth)	183	312	408	486	769

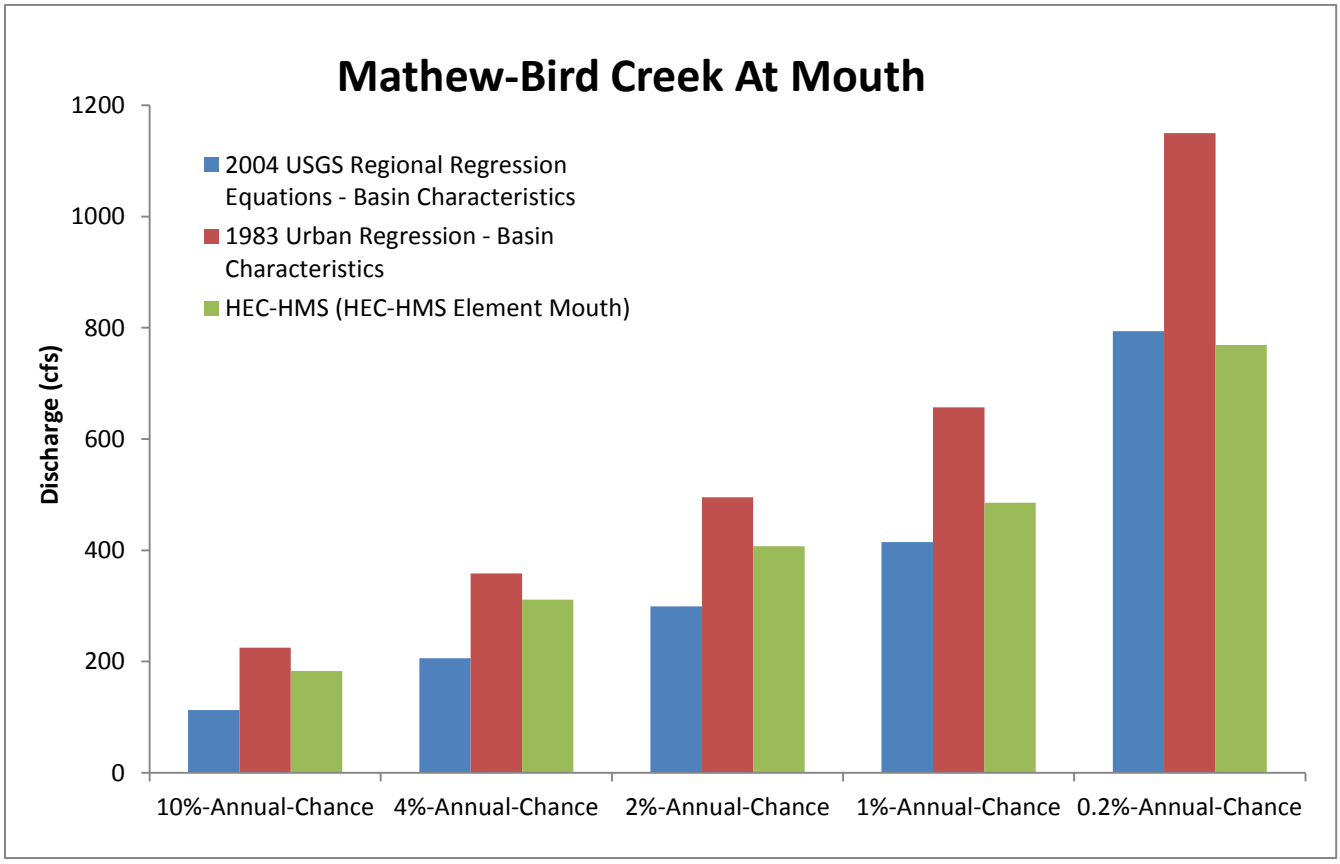

Figure 3-1. Resultant discharges for Mathew-Bird Creek at Mouth

Table 3-3. Resultant discharges for Mathew-Bird Creek Upstream of Garfield Street

Method	Discharge (cfs)				
	10%-Annual-Chance	4%-Annual-Chance	2%-Annual-Chance	1%-Annual-Chance	0.2%-Annual-Chance
2004 USGS Regional Regression Equations - Basin Characteristics	110	200	290	402	771
1983 Urban Regression - Basin Characteristics	220	350	483	640	1120
HEC-HMS (HEC-HMS Element J_USGarfield)	165	282	369	444	737

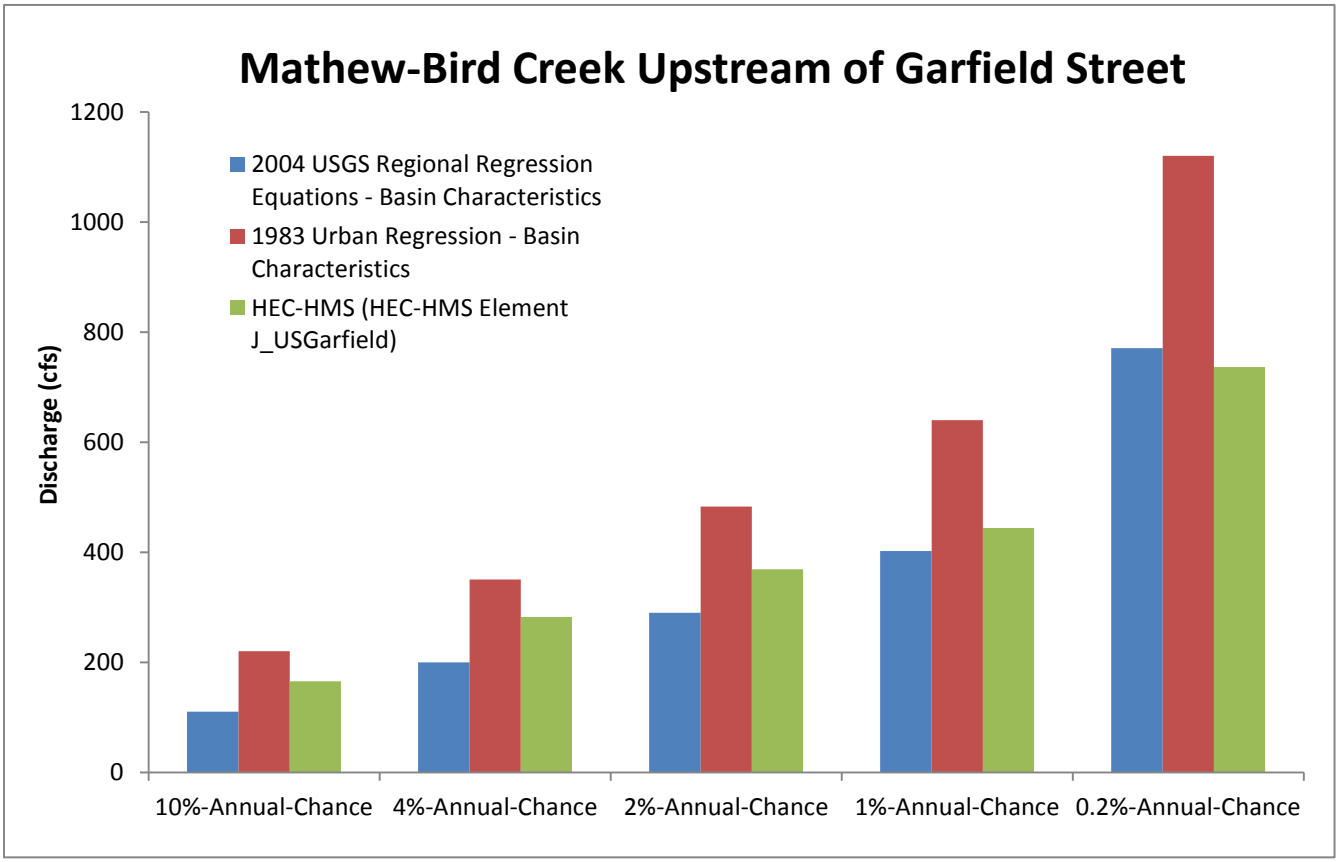

Figure 3-2. Resultant discharges for Mathew-Bird Creek Upstream of Garfield Street

Table 3-4. Resultant discharges for Mathew-Bird Creek Upstream of Figgins Creek

Method	Discharge (cfs)				
	10%-Annual-Chance	4%-Annual-Chance	2%-Annual-Chance	1%-Annual-Chance	0.2%-Annual-Chance
2004 USGS Regional Regression Equations - Basin Characteristics	84	153	222	307	589
1983 Urban Regression - Basin Characteristics	178	283	389	513	900
HEC-HMS (HEC-HMS Element J_USFiggins)	77	158	234	303	490
Effective Discharges	73	*N/A*	143	190	276

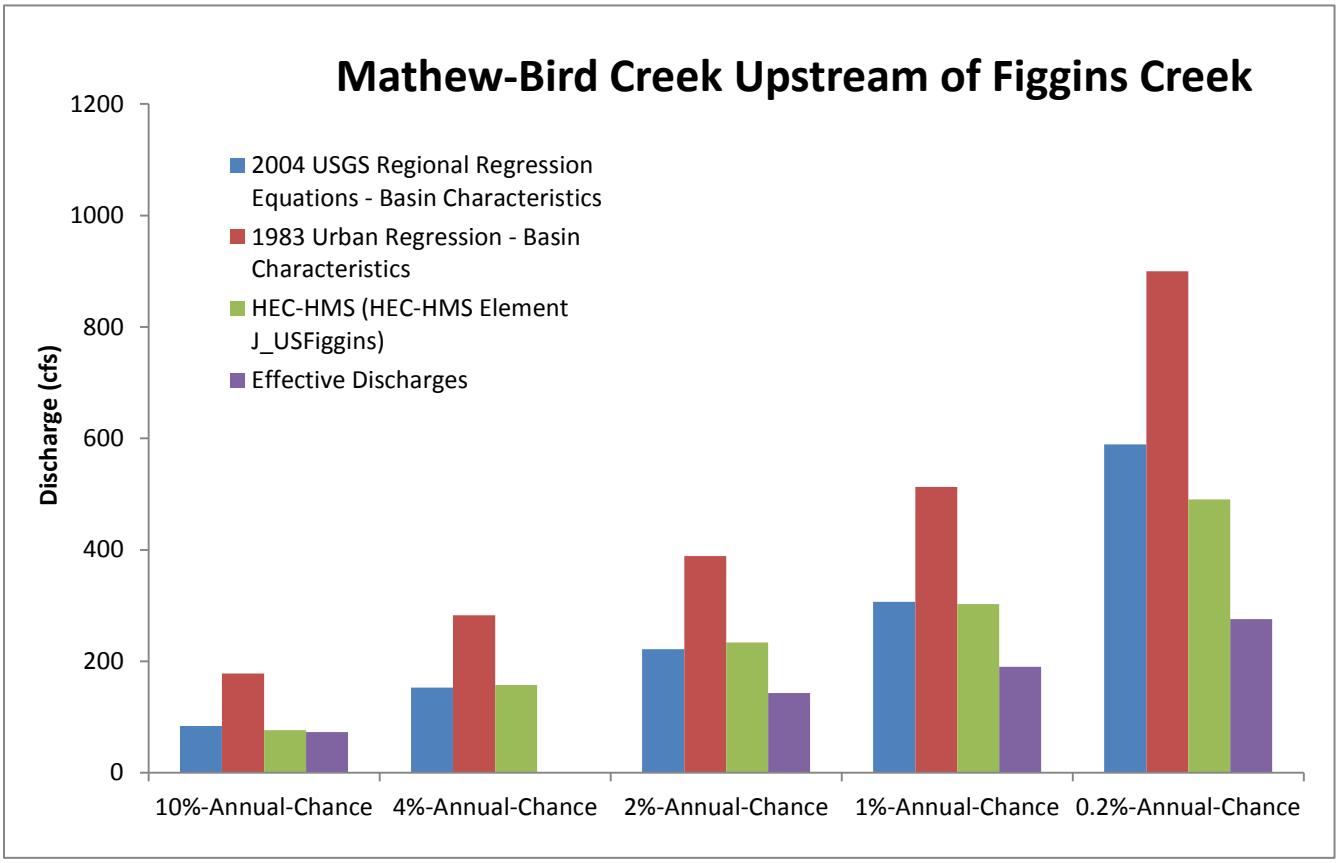

Figure 3-3. Resultant discharges for Mathew-Bird Creek Upstream of Figgins Creek

Table 3-5. Resultant discharges for Mathew-Bird Creek Through Graf Street

Method	Discharge (cfs)				
	10%-Annual-Chance	4%-Annual-Chance	2%-Annual-Chance	1%-Annual-Chance	0.2%-Annual-Chance
2004 USGS Regional Regression Equations - Basin Characteristics	80	145	211	293	560
1983 Urban Regression - Basin Characteristics	171	271	373	494	863
HEC-HMS (HEC-HMS Element J_ThroughGraf)	71	150	224	290	473
Effective Discharges	71	*N/A*	140	186	271

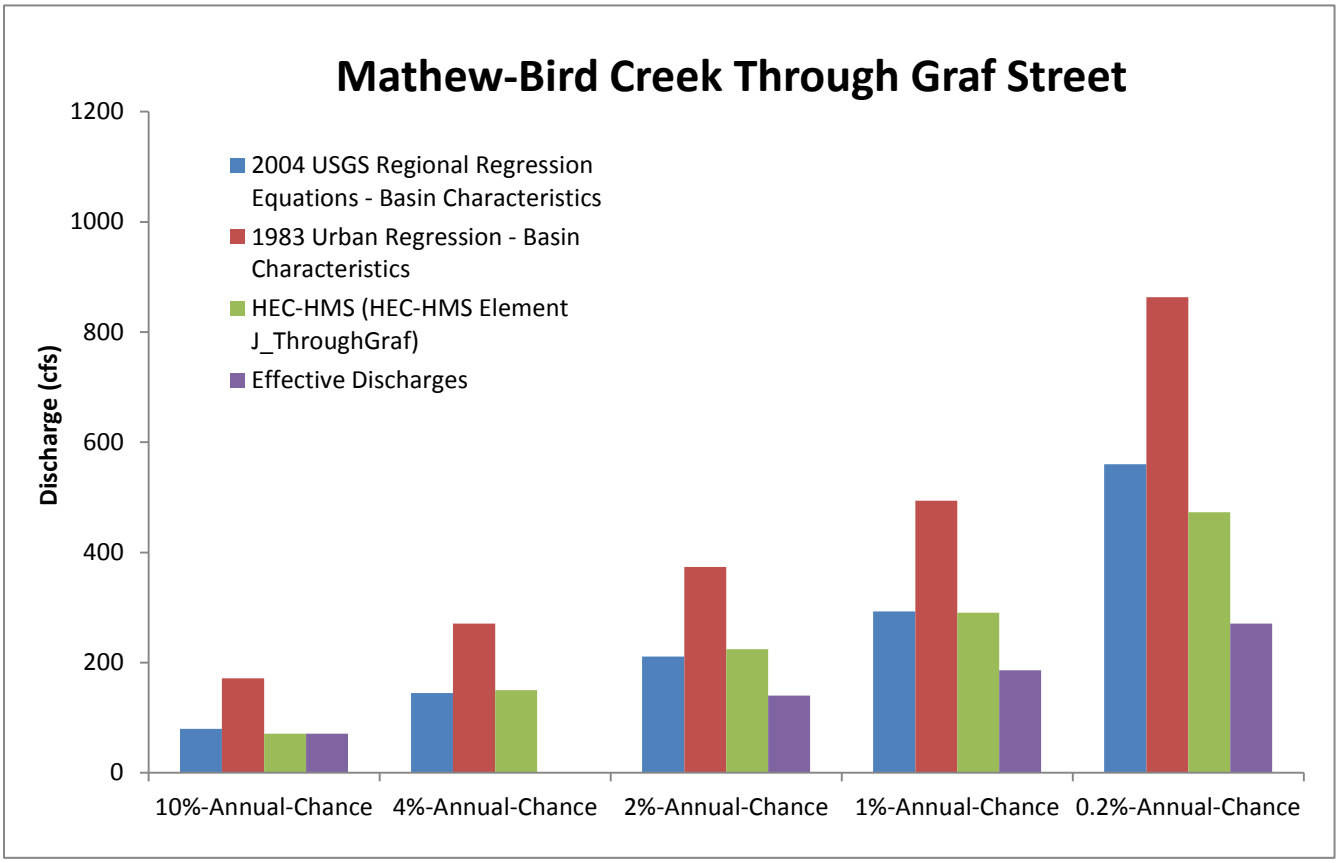

Figure 3-4. Resultant discharges for Mathew-Bird Creek Through Graf Street

Table 3-6. Resultant discharges for Mathew-Bird Creek Near Sundance Drive

Method	Discharge (cfs)				
	10%-Annual-Chance	4%-Annual-Chance	2%-Annual-Chance	1%-Annual-Chance	0.2%-Annual-Chance
2004 USGS Regional Regression Equations - Basin Characteristics	74	135	197	272	520
1983 Urban Regression - Basin Characteristics	161	256	353	465	812
HEC-HMS (HEC-HMS J_Sundance)	62	133	200	260	428

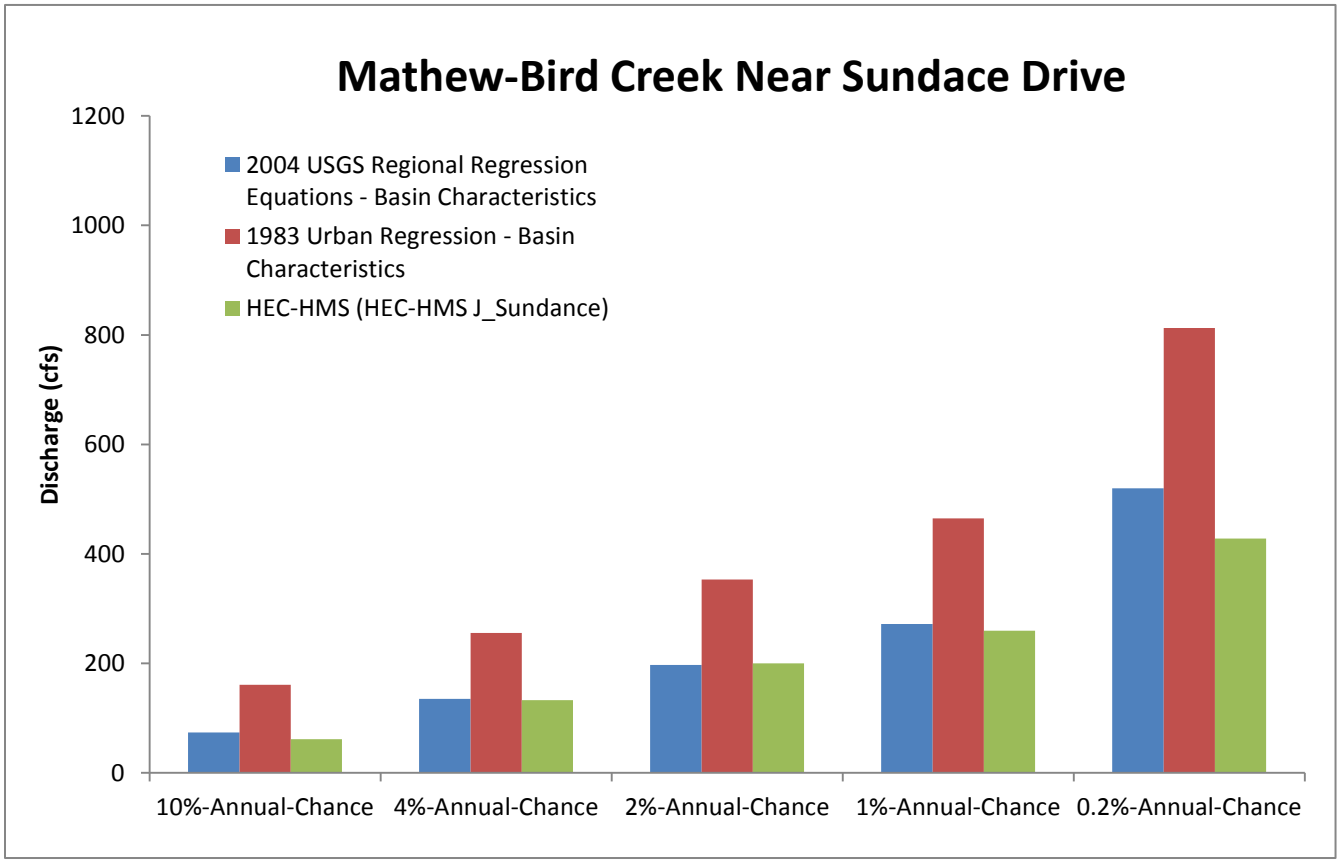

Figure 3-5. Resultant discharges for Mathew-Bird Creek Near Sundance Drive

Table 3-7. Resultant discharges for Mathew-Bird Creek Through Goldenstein Lane

Method	Discharge (cfs)				
	10%-Annual-Chance	4%-Annual-Chance	2%-Annual-Chance	1%-Annual-Chance	0.2%-Annual-Chance
2004 USGS Regional Regression Equations - Basin Characteristics	70	127	185	256	490
1983 Urban Regression - Basin Characteristics[1]	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
HEC-HMS (HEC-HMS Element J_ThroughGoldenstein	56	122	186	242	404
Effective Discharges	65	*N/A*	129	173	251

[1] *methodology not suitable for this location*

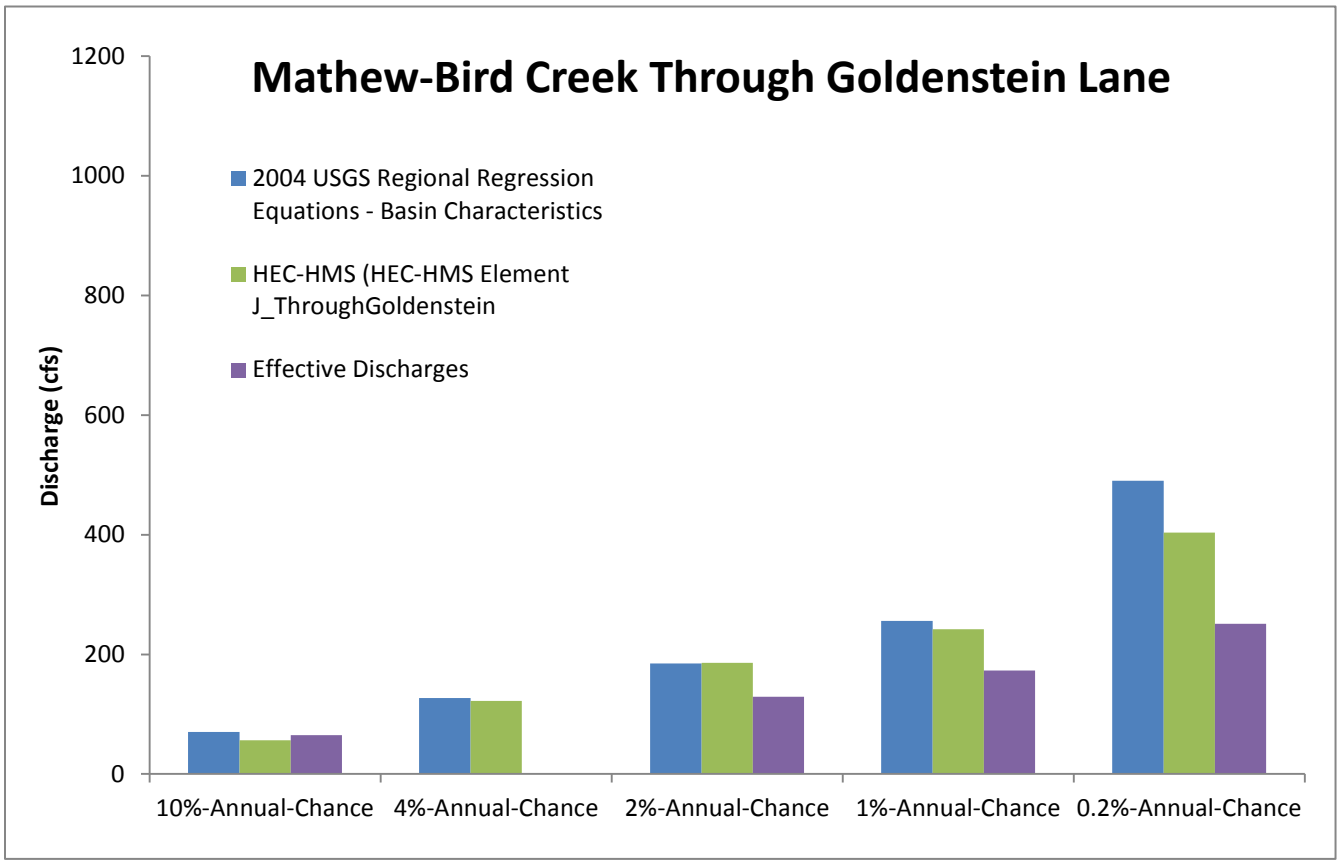

Figure 3-6. Resultant discharges for Mathew-Bird Creek Through Goldenstein Lane

3.2 Discussion and Recommended Discharges

In review of the discharges listed in **Table 3-2** through **Table 3-7**, it is apparent the discharges calculated by weighting the basin characteristics regression equations by the Urban Regression weighting procedure are significantly higher for most locations and events. For the downstream flow nodes where urbanization is prevalent, the urban regression procedure compares reasonably well to the HEC-HMS model. The lower portion of Mathew-Bird Creek is located in an urban environment and has been altered from its natural geomorphic condition in the form of road crossings, developments, bank protection and grade control structures. Additionally, the prevalence of storm drains, curbs, and gutters throughout the lower basin would suggest the Urban Regression weighting procedure is suitable for the flow locations lower in the basin that are more affected by development and imperviousness. It should be noted, that this methodology is based on an urban database from much larger urban areas than Bozeman and Gallatin County. Many of the cities utilized to develop the database are urbanized to a larger degree than Bozeman. Since the degree of urbanization in Bozeman is of smaller scale and the portion of the Mathew-Bird Creek basin that is fully developed is relatively low, estimates generated from this methodology may not accurately characterize the runoff behavior of the system.

Upon initial review, the results generated by basin characteristics regression equations agree well with the results generated by the HEC-HMS model. A closer inspection reveals that flow locations lower in the basin, with more development and urbanization, produce a higher discrepancy to the HEC-HMS model than the results generated for locations higher in the basin that are more rural. The lack of a significant presence of spring-fed dominated creeks, similar to Mathew-Bird Creek, in the Upper Yellowstone-Central Mountain Region sample pool introduces uncertainty as to whether their unique behavior is reflected in the equations developed for this mountain-stream dominated region. It is perceived there are differences in runoff quantity between the basins of traditionally gaged mountain/foothill streams, where annual peak flow corresponds to rapid melting of snowpack, and basins with spring-fed streams, where peak flow is storm based. Since the basin characteristic regression were developed from a sample pool dominated by snow melt driven peak flows, it is anticipated that those equations do not reliably characterize the storm based peak flow event which is expected to control in the Mathew-Bird watershed.

It is noted that discharges calculated for the present study are considerably higher than the effective discharges for Mathew-Bird Creek. This is emphasized on **Figure 3-3**, **Figure 3-4**, and **Figure 3-6** where flow change locations for the present study match some FIS flow changes locations reasonably well, since their drainage areas are quite similar. The FIS Summary of Discharges Table suggests that discharges shown are not generated by the regression equations developed for the FIS, but rather are the result of flow transfer to each basin by uncontrolled irrigation and road ditches. Whether the irrigation ditches mentioned correspond to the Middle Creek Ditch or the Mystic Lake Ditch delivering flow from outside the basin is unknown. It is

also possible the effective discharges are based on a diversion of discharge analysis quantified during development of their hydraulic model.

The Mathew-Bird Creek watershed is likely not suitable for Urban Regression since that database was developed from cities with a much higher degree of urbanization than the City of Bozeman and the Gallatin County. Consequently, it is recommended that those discharges not be utilized for hydraulic modeling. It is important to note however, that results for flow locations where urbanization and development have a higher prevalence generated from Urban Regression agree reasonably well to the HEC-HMS model. Also, it was observed that the basin characteristics regression equation results for flow locations higher in the basin, where conditions are rural agree reasonably well the HEC-HMS model but that methodology does not utilize many gages with similar "spring-fed" characteristics. Since the combination of the two regression methods agree reasonably well to the HEC-HMS model, they serve to justify the use of the HEC-HMS model discharges for hydraulic modelling. This is emphasized in **Figure 3-7** which shows results from various methods plotted to drainage area. The plot also shows the 90% confidence interval of the basin characteristics regression results. Both the HEC-HMS results and the Urban Regression results are within the 90% confidence interval which supports use of the HEC-HMS results. Additionally, the concurrent adjacent flood studies that share drainage basin boundaries are based on HEC-HMS models that utilize the same precipitation values so it is beneficial to provide a consistent methodology between adjacent flood studies, where suitable. Furthermore, these HEC-HMS models may be combined and used by others of the community for other purposes. For these reasons, it is recommended that discharges estimates generated by the HEC-HMS model be utilized for hydraulic modeling.

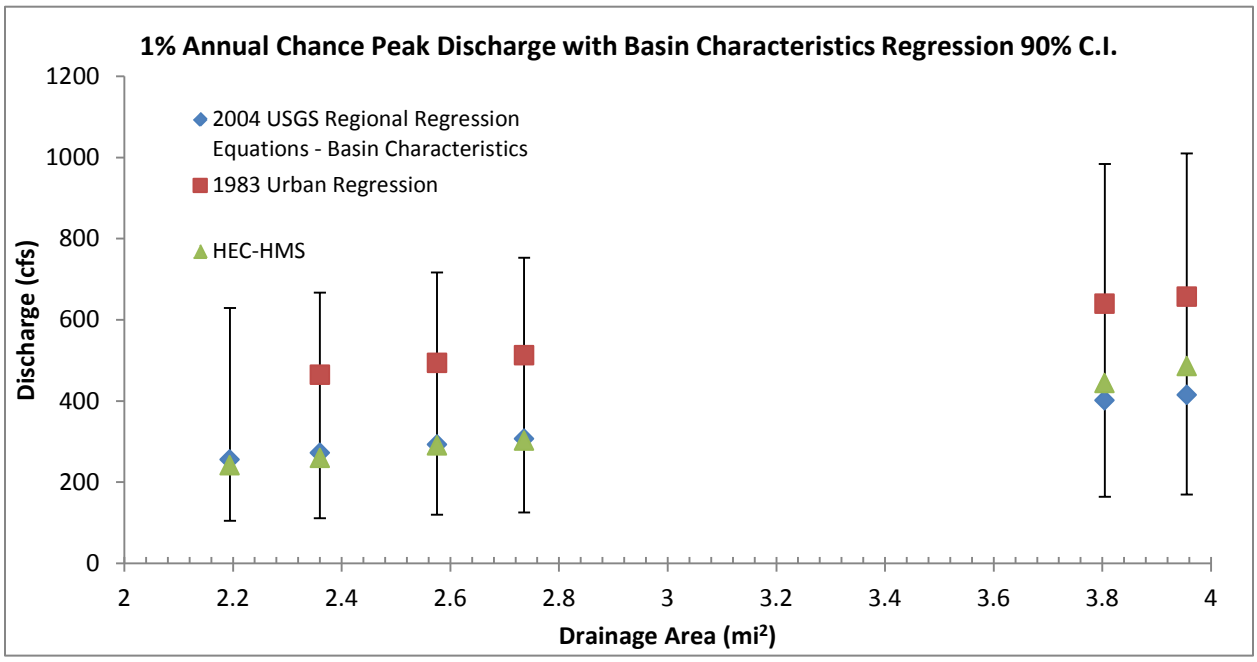

Figure 3-7. Peak discharge by method plot to drainage area with 90% C.I. of Basin Characteristics Regression result.

The flow change locations compared will be utilized in the hydraulic model. For conservatism, flows developed at the mouth will be utilized upstream to the next flow change location (Upstream of Garfield Street). Similarly, flows estimated Upstream of Garfield Street will be used in the hydraulic model to the next upstream flow change location. For the Through Goldenstein Lane flow change location, the HEC-HMS model contains a subbasin and routing reach that enter Mathew-Bird Creek at the upstream side of the roadway. It is over conservative to utilize those flow inputs upstream (since they contribute significant drainage area) so an additional junction was used in the HEC-HMS model to provide more reasonable discharges upstream of that location. The discharge estimates calculated for Through Goldenstein Lane will be utilized through the roadway but the additional junction established allows for the additional flow change location Upstream of Goldenstein Lane. This additional flow change location corresponds to HEC-HMS Element J_USGoldenstein and is shown graphically on **Figure 1-1** and **Figure 2-2**. Those discharge estimates are provided in **Table 3-8** along with the previously presented discharge estimates.

Recommended 10-, 4-, 2-, 1- and 0.2-percent annual chance discharges for all locations of Mathew-Bird Creek are presented below in **Table 3-8**.

Table 3-8. Recommended discharges for Mathew-Bird Creek

Location	Drainage Area (mi^2)	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 Mouth	3.96	183	312	408	486	769
Upstream of Garfield Street	3.80	165	282	369	444	737
Upstream of Figgins Creek	2.74	77	158	234	303	490
Through Graf Street	2.58	71	150	224	290	473
Near Sundance Drive	2.20	62	133	200	260	428
Through Goldenstein Lane	2.03	56	122	186	242	404
Upstream of Goldenstein Lane	0.28	19	34	47	58	88

4. REFERENCES

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Appendix A. Regression Analysis

USGS

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:	**Mathew Bird - Mouth**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics and Active-channel width**
Drainage area in square miles:	**3.955403**
Percent basin above 6,000 feet:	**.91**
Width of active channel in feet:	**6**

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
 Mathew Bird - Mouth
Upper Yellowstone-Central Mountain Region: A =      3.96 E6 =     1.
 RI        DISCHARGE  STD ERR OF                90% PRED. INTERVAL
             (cfs)      PREDICTION(%)
     2         20.        95.2                5.1                74.
     5         62.        73.3               21.0               185.
    10        113.        64.2               42.6               300.
    25        206.        58.1               84.0               504.
    50        299.        57.0              124.0               722.
   100        415.        58.1              169.4              1010.
   200        557.        60.9              219.4              1420.
   500        794.        66.7              290.3              2170.


 METHOD: Regression on active channel width
 Flood frequency estimates for
```

Mathew Bird - Mouth
Upper Yellowstone-Central Mountain Region: WAC = 6.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	37.	71.8	12.8	110.
5	103.	68.1	36.7	289.
10	175.	70.1	61.0	504.
25	304.	75.8	98.8	937.
50	434.	82.1	130.9	1440.
100	593.	89.3	165.1	2130.
200	788.	97.7	200.9	3090.
500	1110.	110.2	250.1	4920.

METHOD: Combined methods 1 and 2
Flood frequency estimates for
Mathew Bird - Mouth
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	31.	67.2	11.3	86.
5	82.	58.0	33.7	201.
10	137.	55.3	58.0	322.
25	230.	54.6	98.4	537.
50	320.	55.7	134.9	758.
100	429.	57.7	176.1	1040.
200	562.	60.8	221.4	1430.
500	794.	66.7	290.3	2170.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - 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:	**3.955403**
Percent basin above 6,000 feet:	**0.91**
Width of active channel in feet:	**6**
Width of bank full channel in feet:	**9.5**

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
 Mathew Bird - Mouth
Upper Yellowstone-Central Mountain Region: A =      3.96 E6 =     1.
 RI       DISCHARGE  STD ERR OF              90% PRED. INTERVAL
            (cfs)      PREDICTION(%)
     2        20.        95.2              5.1              74.
     5        62.        73.3             21.0             185.
    10       113.        64.2             42.6             300.
    25       206.        58.1             84.0             504.
    50       299.        57.0            124.0             722.
   100       415.        58.1            169.4            1010.
   200       557.        60.9            219.4            1420.
   500       794.        66.7            290.3            2170.
```

METHOD: Regression on active channel width
Flood frequency estimates for
Mathew Bird - Mouth
Upper Yellowstone-Central Mountain Region: WAC = 6.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	37.	71.8	12.8	110.
5	103.	68.1	36.7	289.
10	175.	70.1	61.0	504.
25	304.	75.8	98.8	937.
50	434.	82.1	130.9	1440.
100	593.	89.3	165.1	2130.
200	788.	97.7	200.9	3090.
500	1110.	110.2	250.1	4920.

METHOD: Regression on bank full channel width
Flood frequency estimates for
Mathew Bird - Mouth
Upper Yellowstone-Central Mountain Region: WBF = 9.50

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	39.	159.9	5.9	253.
5	91.	72.7	30.6	270.
10	154.	73.7	51.3	462.
25	267.	79.1	83.3	853.
50	380.	85.4	110.5	1310.
100	520.	92.8	139.4	1940.
200	693.	101.5	169.9	2820.
500	977.	114.5	211.8	4510.

METHOD: Combined methods 1, 2 and 3
Flood frequency estimates for
Mathew Bird - Mouth
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	31.	67.2	11.3	86.
5	80.	53.1	35.2	184.
10	134.	52.0	59.4	301.
25	227.	53.0	99.2	518.
50	318.	55.0	135.3	746.
100	429.	57.7	176.1	1040.
200	562.	60.8	221.4	1430.
500	794.	66.7	290.3	2170.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - Mouth**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics and Bankfull width**
Drainage area in square miles:	**3.955403**
Percent basin above 6,000 feet:	**.91**
Width of bank full channel in feet:	**9.5**

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
 Mathew Bird - Mouth
Upper Yellowstone-Central Mountain Region: A =      3.96 E6 =     1.
 RI        DISCHARGE  STD ERR OF                90% PRED. INTERVAL
             (cfs)      PREDICTION(%)
     2         20.        95.2                5.1                74.
     5         62.        73.3               21.0               185.
    10        113.        64.2               42.6               300.
    25        206.        58.1               84.0               504.
    50        299.        57.0              124.0               722.
   100        415.        58.1              169.4              1010.
   200        557.        60.9              219.4              1420.
   500        794.        66.7              290.3              2170.
```

```
 METHOD: Regression on bank full channel width
 Flood frequency estimates for
```

Mathew Bird - Mouth
Upper Yellowstone-Central Mountain Region: WBF = 9.50

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	39.	159.9	5.9	253.
5	91.	72.7	30.6	270.
10	154.	73.7	51.3	462.
25	267.	79.1	83.3	853.
50	380.	85.4	110.5	1310.
100	520.	92.8	139.4	1940.
200	693.	101.5	169.9	2820.
500	977.	114.5	211.8	4510.

METHOD: Combined methods 1 and 3
Flood frequency estimates for
Mathew Bird - Mouth
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	23.	89.4	6.4	81.
5	75.	58.7	30.5	186.
10	128.	55.5	54.1	303.
25	220.	54.7	94.3	515.
50	311.	55.7	131.3	739.
100	422.	57.8	173.4	1030.
200	559.	60.9	220.1	1420.
500	794.	66.7	290.3	2170.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - Mouth**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Active-channel width and Bankfull width**
Width of active channel in feet:	**6**
Width of bank full channel in feet:	**9.5**

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 active channel width
 Flood frequency estimates for
 Mathew Bird - Mouth
Upper Yellowstone-Central Mountain Region: WAC =      6.00
 RI       DISCHARGE  STD ERR OF              90% PRED. INTERVAL
            (cfs)      PREDICTION(%)
     2        37.        71.8              12.8              110.
     5       103.        68.1              36.7              289.
    10       175.        70.1              61.0              504.
    25       304.        75.8              98.8              937.
    50       434.        82.1             130.9             1440.
   100       593.        89.3             165.1             2130.
   200       788.        97.7             200.9             3090.
   500      1110.       110.2             250.1             4920.


 METHOD: Regression on bank full channel width
 Flood frequency estimates for
          Mathew Bird - Mouth
Upper Yellowstone-Central Mountain Region: WBF =      9.50
```

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	39.	159.9	5.9	253.
5	91.	72.7	30.6	270.
10	154.	73.7	51.3	462.
25	267.	79.1	83.3	853.
50	380.	85.4	110.5	1310.
100	520.	92.8	139.4	1940.
200	693.	101.5	169.9	2820.
500	977.	114.5	211.8	4510.

METHOD: Combined methods 2 and 3
Flood frequency estimates for
Mathew Bird - Mouth
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	37.	71.8	12.8	109.
5	100.	67.7	36.1	277.
10	171.	69.8	60.0	486.
25	300.	75.7	98.1	917.
50	433.	82.1	131.6	1430.
100	593.	89.3	166.4	2110.
200	788.	97.7	202.6	3070.
500	1110.	110.2	252.4	4870.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - Garfield**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics and Active-channel width**
Drainage area in square miles:	**3.804427**
Percent basin above 6,000 feet:	**.94**
Width of active channel in feet:	**7.5**

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
 Mathew Bird - Garfield
Upper Yellowstone-Central Mountain Region: A =      3.80 E6 =     1.
 RI        DISCHARGE  STD ERR OF                90% PRED. INTERVAL
             (cfs)      PREDICTION(%)
     2         19.        95.3                5.0                72.
     5         60.        73.3               20.3               179.
    10        110.        64.2               41.3               290.
    25        200.        58.1               81.5               489.
    50        290.        57.1              120.2               700.
   100        402.        58.1              164.3               984.
   200        541.        60.9              212.8              1370.
   500        771.        66.7              281.6              2110.


 METHOD: Regression on active channel width
 Flood frequency estimates for
```

Mathew Bird - Garfield
Upper Yellowstone-Central Mountain Region: WAC = 7.50

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	53.	71.6	18.0	154.
5	138.	67.8	49.2	384.
10	228.	69.7	79.6	652.
25	385.	75.4	125.7	1180.
50	540.	81.6	163.7	1780.
100	727.	88.7	203.6	2600.
200	954.	97.1	244.7	3720.
500	1320.	109.5	300.1	5820.

METHOD: Combined methods 1 and 2
Flood frequency estimates for
Mathew Bird - Garfield
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	39.	67.0	14.4	109.
5	95.	57.8	39.1	233.
10	151.	55.2	64.1	355.
25	241.	54.5	103.3	562.
50	325.	55.6	137.3	770.
100	426.	57.7	175.1	1040.
200	549.	60.8	216.4	1390.
500	771.	66.7	281.6	2110.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - Garfield**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics, Active-channel width, and Bankfull width**
Drainage area in square miles:	**3.804427**
Percent basin above 6,000 feet:	**.94**
Width of active channel in feet:	**7.5**
Width of bank full channel in feet:	**12**

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
 Mathew Bird - Garfield
Upper Yellowstone-Central Mountain Region: A =      3.80 E6 =     1.
 RI       DISCHARGE  STD ERR OF              90% PRED. INTERVAL
            (cfs)      PREDICTION(%)
     2        19.        95.3              5.0              72.
     5        60.        73.3             20.3             179.
    10       110.        64.2             41.3             290.
    25       200.        58.1             81.5             489.
    50       290.        57.1            120.2             700.
   100       402.        58.1            164.3             984.
   200       541.        60.9            212.8            1370.
   500       771.        66.7            281.6            2110.
```

METHOD: Regression on active channel width
Flood frequency estimates for
Mathew Bird - Garfield
Upper Yellowstone-Central Mountain Region: WAC = 7.50

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	53.	71.6	18.0	154.
5	138.	67.8	49.2	384.
10	228.	69.7	79.6	652.
25	385.	75.4	125.7	1180.
50	540.	81.6	163.7	1780.
100	727.	88.7	203.6	2600.
200	954.	97.1	244.7	3720.
500	1320.	109.5	300.1	5820.

METHOD: Regression on bank full channel width
Flood frequency estimates for
Mathew Bird - Garfield
Upper Yellowstone-Central Mountain Region: WBF = 12.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	58.	159.5	8.9	382.
5	130.	72.3	43.8	383.
10	213.	73.2	71.2	636.
25	357.	78.5	112.3	1140.
50	499.	84.8	146.1	1710.
100	671.	92.1	181.4	2490.
200	880.	100.7	217.7	3560.
500	1220.	113.6	266.6	5570.

METHOD: Combined methods 1, 2 and 3
Flood frequency estimates for
Mathew Bird - Garfield
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	39.	67.0	14.4	109.
5	95.	52.9	41.5	216.
10	149.	51.9	66.4	336.
25	239.	52.9	104.8	545.
50	324.	54.9	138.0	759.
100	426.	57.7	175.1	1040.
200	549.	60.8	216.4	1390.
500	771.	66.7	281.6	2110.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - Garfield**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics and Bankfull width**
Drainage area in square miles:	**3.804427**
Percent basin above 6,000 feet:	**.94**
Width of bank full channel in feet:	**12**

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
 Mathew Bird - Garfield
Upper Yellowstone-Central Mountain Region: A =      3.80 E6 =     1.
 RI       DISCHARGE  STD ERR OF              90% PRED. INTERVAL
            (cfs)      PREDICTION(%)
     2        19.        95.3              5.0              72.
     5        60.        73.3             20.3             179.
    10       110.        64.2             41.3             290.
    25       200.        58.1             81.5             489.
    50       290.        57.1            120.2             700.
   100       402.        58.1            164.3             984.
   200       541.        60.9            212.8            1370.
   500       771.        66.7            281.6            2110.
```

```
 METHOD: Regression on bank full channel width
 Flood frequency estimates for
```

Mathew Bird - Garfield
Upper Yellowstone-Central Mountain Region: WBF = 12.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	58.	159.5	8.9	382.
5	130.	72.3	43.8	383.
10	213.	73.2	71.2	636.
25	357.	78.5	112.3	1140.
50	499.	84.8	146.1	1710.
100	671.	92.1	181.4	2490.
200	880.	100.7	217.7	3560.
500	1220.	113.6	266.6	5570.

METHOD: Combined methods 1 and 3
Flood frequency estimates for
Mathew Bird - Garfield
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	24.	89.4	6.9	87.
5	89.	58.5	36.2	219.
10	144.	55.4	60.9	339.
25	234.	54.6	100.0	545.
50	319.	55.7	134.4	755.
100	421.	57.7	172.7	1020.
200	545.	60.9	214.7	1380.
500	771.	66.7	281.6	2110.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - Garfield**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Active-channel width and Bankfull width**
Width of active channel in feet:	**7.5**
Width of bank full channel in feet:	**12**

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 active channel width
 Flood frequency estimates for
 Mathew Bird - Garfield
Upper Yellowstone-Central Mountain Region: WAC =      7.50
 RI       DISCHARGE  STD ERR OF              90% PRED. INTERVAL
            (cfs)      PREDICTION(%)
     2         53.        71.6              18.0              154.
     5        138.        67.8              49.2              384.
    10        228.        69.7              79.6              652.
    25        385.        75.4             125.7             1180.
    50        540.        81.6             163.7             1780.
   100        727.        88.7             203.6             2600.
   200        954.        97.1             244.7             3720.
   500       1320.       109.5             300.1             5820.


 METHOD: Regression on bank full channel width
 Flood frequency estimates for
          Mathew Bird - Garfield
Upper Yellowstone-Central Mountain Region: WBF =     12.00
```

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	58.	159.5	8.9	382.
5	130.	72.3	43.8	383.
10	213.	73.2	71.2	636.
25	357.	78.5	112.3	1140.
50	499.	84.8	146.1	1710.
100	671.	92.1	181.4	2490.
200	880.	100.7	217.7	3560.
500	1220.	113.6	266.6	5570.

METHOD: Combined methods 2 and 3
Flood frequency estimates for
Mathew Bird - Garfield
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	53.	71.6	18.1	153.
5	136.	67.3	49.1	374.
10	225.	69.5	79.3	636.
25	382.	75.3	125.4	1160.
50	539.	81.6	164.5	1760.
100	727.	88.7	205.2	2580.
200	954.	97.1	246.7	3690.
500	1320.	109.5	302.8	5770.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - US Figgins**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics and Active-channel width**
Drainage area in square miles:	**2.735754**
Percent basin above 6,000 feet:	**1.31**
Width of active channel in feet:	**10**

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
 Mathew Bird - US Figgins
Upper Yellowstone-Central Mountain Region: A =      2.74 E6 =     1.
 RI       DISCHARGE  STD ERR OF              90% PRED. INTERVAL
            (cfs)      PREDICTION(%)
     2        15.        95.4              3.9              56.
     5        46.        73.4             15.6             138.
    10        84.        64.3             31.6             223.
    25       153.        58.2             62.3             374.
    50       222.        57.1             91.9             536.
   100       307.        58.2            125.5             753.
   200       413.        61.0            162.5            1050.
   500       589.        66.8            214.8            1610.
```

```
 METHOD: Regression on active channel width
 Flood frequency estimates for
```

Mathew Bird - US Figgins
Upper Yellowstone-Central Mountain Region: WAC = 10.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	82.	71.3	28.0	238.
5	200.	67.5	71.7	555.
10	319.	69.3	112.2	910.
25	522.	74.9	171.1	1590.
50	715.	81.1	218.2	2350.
100	945.	88.2	266.5	3350.
200	1220.	96.4	314.9	4720.
500	1660.	108.7	379.1	7240.

METHOD: Combined methods 1 and 2
Flood frequency estimates for
Mathew Bird - US Figgins
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	51.	66.9	18.5	139.
5	105.	57.7	43.2	256.
10	152.	55.1	64.6	357.
25	219.	54.5	93.8	510.
50	277.	55.6	116.9	655.
100	346.	57.7	141.9	842.
200	429.	60.9	168.7	1090.
500	589.	66.8	214.8	1610.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - US Figgins**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics, Active-channel width, and Bankfull width**
Drainage area in square miles:	**2.735754**
Percent basin above 6,000 feet:	**1.31**
Width of active channel in feet:	**10**
Width of bank full channel in feet:	**13**

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
 Mathew Bird - US Figgins
Upper Yellowstone-Central Mountain Region: A =      2.74 E6 =     1.
 RI       DISCHARGE  STD ERR OF              90% PRED. INTERVAL
            (cfs)      PREDICTION(%)
     2        15.        95.4              3.9              56.
     5        46.        73.4             15.6             138.
    10        84.        64.3             31.6             223.
    25       153.        58.2             62.3             374.
    50       222.        57.1             91.9             536.
   100       307.        58.2            125.5             753.
   200       413.        61.0            162.5            1050.
   500       589.        66.8            214.8            1610.
```

METHOD: Regression on active channel width
Flood frequency estimates for
Mathew Bird - US Figgins
Upper Yellowstone-Central Mountain Region: WAC = 10.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	82.	71.3	28.0	238.
5	200.	67.5	71.7	555.
10	319.	69.3	112.2	910.
25	522.	74.9	171.1	1590.
50	715.	81.1	218.2	2350.
100	945.	88.2	266.5	3350.
200	1220.	96.4	314.9	4720.
500	1660.	108.7	379.1	7240.

METHOD: Regression on bank full channel width
Flood frequency estimates for
Mathew Bird - US Figgins
Upper Yellowstone-Central Mountain Region: WBF = 13.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	67.	159.4	10.3	440.
5	146.	72.2	49.6	432.
10	238.	73.1	79.7	709.
25	395.	78.4	124.3	1250.
50	548.	84.6	160.8	1870.
100	733.	91.9	198.4	2710.
200	956.	100.4	236.9	3850.
500	1320.	113.3	288.4	6000.

METHOD: Combined methods 1, 2 and 3
Flood frequency estimates for
Mathew Bird - US Figgins
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	51.	66.9	18.5	139.
5	100.	52.8	43.8	227.
10	145.	51.7	64.6	325.
25	213.	52.9	93.5	486.
50	274.	55.1	116.7	645.
100	346.	57.7	141.9	842.
200	429.	60.9	168.7	1090.
500	589.	66.8	214.8	1610.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - US Figgins**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics and Bankfull width**
Drainage area in square miles:	**2.735754**
Percent basin above 6,000 feet:	**1.31**
Width of bank full channel in feet:	**13**

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
 Mathew Bird - US Figgins
Upper Yellowstone-Central Mountain Region: A =      2.74 E6 =     1.
 RI        DISCHARGE  STD ERR OF                90% PRED. INTERVAL
             (cfs)      PREDICTION(%)
     2         15.        95.4                3.9                56.
     5         46.        73.4               15.6               138.
    10         84.        64.3               31.6               223.
    25        153.        58.2               62.3               374.
    50        222.        57.1               91.9               536.
   100        307.        58.2              125.5               753.
   200        413.        61.0              162.5              1050.
   500        589.        66.8              214.8              1610.
```

```
 METHOD: Regression on bank full channel width
 Flood frequency estimates for
```

Mathew Bird - US Figgins
Upper Yellowstone-Central Mountain Region: WBF = 13.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	67.	159.4	10.3	440.
5	146.	72.2	49.6	432.
10	238.	73.1	79.7	709.
25	395.	78.4	124.3	1250.
50	548.	84.6	160.8	1870.
100	733.	91.9	198.4	2710.
200	956.	100.4	236.9	3850.
500	1320.	113.3	288.4	6000.

METHOD: Combined methods 1 and 3
Flood frequency estimates for
Mathew Bird - US Figgins
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	21.	89.5	5.8	74.
5	83.	58.5	33.9	205.
10	129.	55.4	54.5	304.
25	198.	54.7	84.7	462.
50	260.	55.7	109.6	616.
100	333.	57.8	136.4	811.
200	420.	60.9	165.3	1070.
500	589.	66.8	214.8	1610.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - US Figgins**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Active-channel width and Bankfull width**
Width of active channel in feet:	**10**
Width of bank full channel in feet:	**13**

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 active channel width
 Flood frequency estimates for
 Mathew Bird - US Figgins
Upper Yellowstone-Central Mountain Region: WAC =     10.00
 RI       DISCHARGE  STD ERR OF              90% PRED. INTERVAL
            (cfs)      PREDICTION(%)
     2        82.        71.3              28.0              238.
     5       200.        67.5              71.7              555.
    10       319.        69.3             112.2              910.
    25       522.        74.9             171.1             1590.
    50       715.        81.1             218.2             2350.
   100       945.        88.2             266.5             3350.
   200      1220.        96.4             314.9             4720.
   500      1660.       108.7             379.1             7240.
```

```
 METHOD: Regression on bank full channel width
 Flood frequency estimates for
          Mathew Bird - US Figgins
Upper Yellowstone-Central Mountain Region: WBF =     13.00
```

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	67.	159.4	10.3	440.
5	146.	72.2	49.6	432.
10	238.	73.1	79.7	709.
25	395.	78.4	124.3	1250.
50	548.	84.6	160.8	1870.
100	733.	91.9	198.4	2710.
200	956.	100.4	236.9	3850.
500	1320.	113.3	288.4	6000.

METHOD: Combined methods 2 and 3
Flood frequency estimates for
Mathew Bird - US Figgins
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	82.	71.3	28.2	237.
5	186.	67.1	67.7	512.
10	302.	69.1	107.1	853.
25	509.	74.9	168.3	1540.
50	715.	81.1	219.8	2330.
100	945.	88.2	268.5	3330.
200	1220.	96.4	317.5	4690.
500	1660.	108.7	382.4	7180.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - US Graf**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics and Active-channel width**
Drainage area in square miles:	**2.575477**
Percent basin above 6,000 feet:	**1.39**
Width of active channel in feet:	**8**

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
 Mathew Bird - US Graf
Upper Yellowstone-Central Mountain Region: A =      2.58 E6 =     1.
 RI        DISCHARGE  STD ERR OF                90% PRED. INTERVAL
             (cfs)      PREDICTION(%)
     2         14.        95.5                3.7                53.
     5         44.        73.5               14.9               132.
    10         80.        64.3               30.1               212.
    25        145.        58.2               59.3               356.
    50        211.        57.2               87.4               511.
   100        293.        58.2              119.4               717.
   200        393.        61.0              154.6              1000.
   500        560.        66.8              204.3              1540.


 METHOD: Regression on active channel width
 Flood frequency estimates for
```

Mathew Bird - US Graf
Upper Yellowstone-Central Mountain Region: WAC = 8.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	58.	71.5	19.9	170.
5	150.	67.8	53.6	417.
10	246.	69.6	86.0	702.
25	412.	75.2	134.7	1260.
50	575.	81.5	174.6	1890.
100	771.	88.6	216.3	2750.
200	1010.	96.9	259.0	3920.
500	1390.	109.3	316.3	6110.

METHOD: Combined methods 1 and 2
Flood frequency estimates for
Mathew Bird - US Graf
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	39.	67.0	14.2	107.
5	87.	57.8	35.8	213.
10	131.	55.2	55.7	309.
25	197.	54.6	84.2	459.
50	254.	55.7	107.3	603.
100	323.	57.8	132.4	786.
200	405.	60.9	159.2	1030.
500	560.	66.8	204.3	1540.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - US Graf**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics, Active-channel width, and Bankfull width**
Drainage area in square miles:	**2.575477**
Percent basin above 6,000 feet:	**1.39**
Width of active channel in feet:	**8**
Width of bank full channel in feet:	**13**

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
 Mathew Bird - US Graf
Upper Yellowstone-Central Mountain Region: A =      2.58 E6 =     1.
 RI       DISCHARGE  STD ERR OF              90% PRED. INTERVAL
            (cfs)      PREDICTION(%)
     2        14.        95.5              3.7              53.
     5        44.        73.5             14.9             132.
    10        80.        64.3             30.1             212.
    25       145.        58.2             59.3             356.
    50       211.        57.2             87.4             511.
   100       293.        58.2            119.4             717.
   200       393.        61.0            154.6            1000.
   500       560.        66.8            204.3            1540.
```

METHOD: Regression on active channel width
Flood frequency estimates for
Mathew Bird - US Graf
Upper Yellowstone-Central Mountain Region: WAC = 8.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	58.	71.5	19.9	170.
5	150.	67.8	53.6	417.
10	246.	69.6	86.0	702.
25	412.	75.2	134.7	1260.
50	575.	81.5	174.6	1890.
100	771.	88.6	216.3	2750.
200	1010.	96.9	259.0	3920.
500	1390.	109.3	316.3	6110.

METHOD: Regression on bank full channel width
Flood frequency estimates for
Mathew Bird - US Graf
Upper Yellowstone-Central Mountain Region: WBF = 13.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	67.	159.4	10.3	440.
5	146.	72.2	49.6	432.
10	238.	73.1	79.7	709.
25	395.	78.4	124.3	1250.
50	548.	84.6	160.8	1870.
100	733.	91.9	198.4	2710.
200	956.	100.4	236.9	3850.
500	1320.	113.3	288.4	6000.

METHOD: Combined methods 1, 2 and 3
Flood frequency estimates for
Mathew Bird - US Graf
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	39.	67.0	14.2	107.
5	87.	52.9	38.3	199.
10	131.	51.9	58.1	294.
25	196.	53.0	85.7	447.
50	254.	55.0	108.1	595.
100	323.	57.8	132.4	786.
200	405.	60.9	159.2	1030.
500	560.	66.8	204.3	1540.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - US Graf**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics and Bankfull width**
Drainage area in square miles:	**2.575477**
Percent basin above 6,000 feet:	**1.39**
Width of bank full channel in feet:	**13**

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
 Mathew Bird - US Graf
Upper Yellowstone-Central Mountain Region: A =      2.58 E6 =     1.
 RI        DISCHARGE  STD ERR OF                90% PRED. INTERVAL
             (cfs)      PREDICTION(%)
     2         14.        95.5               3.7                53.
     5         44.        73.5              14.9               132.
    10         80.        64.3              30.1               212.
    25        145.        58.2              59.3               356.
    50        211.        57.2              87.4               511.
   100        293.        58.2             119.4               717.
   200        393.        61.0             154.6              1000.
   500        560.        66.8             204.3              1540.
```

```
 METHOD: Regression on bank full channel width
 Flood frequency estimates for
```

Mathew Bird - US Graf
Upper Yellowstone-Central Mountain Region: WBF = 13.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	67.	159.4	10.3	440.
5	146.	72.2	49.6	432.
10	238.	73.1	79.7	709.
25	395.	78.4	124.3	1250.
50	548.	84.6	160.8	1870.
100	733.	91.9	198.4	2710.
200	956.	100.4	236.9	3850.
500	1320.	113.3	288.4	6000.

METHOD: Combined methods 1 and 3
Flood frequency estimates for
Mathew Bird - US Graf
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	20.	89.5	5.6	72.
5	82.	58.5	33.1	201.
10	125.	55.4	53.0	296.
25	191.	54.7	81.7	446.
50	250.	55.7	105.2	592.
100	318.	57.8	130.4	776.
200	400.	61.0	157.4	1020.
500	560.	66.8	204.3	1540.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - US Graf**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Active-channel width and Bankfull width**
Width of active channel in feet:	**8**
Width of bank full channel in feet:	**13**

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 active channel width
 Flood frequency estimates for
 Mathew Bird - US Graf
Upper Yellowstone-Central Mountain Region: WAC =      8.00
 RI       DISCHARGE  STD ERR OF              90% PRED. INTERVAL
            (cfs)      PREDICTION(%)
     2         58.        71.5              19.9              170.
     5        150.        67.8              53.6              417.
    10        246.        69.6              86.0              702.
    25        412.        75.2             134.7             1260.
    50        575.        81.5             174.6             1890.
   100        771.        88.6             216.3             2750.
   200       1010.        96.9             259.0             3920.
   500       1390.       109.3             316.3             6110.


 METHOD: Regression on bank full channel width
 Flood frequency estimates for
          Mathew Bird - US Graf
Upper Yellowstone-Central Mountain Region: WBF =     13.00
```

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	67.	159.4	10.3	440.
5	146.	72.2	49.6	432.
10	238.	73.1	79.7	709.
25	395.	78.4	124.3	1250.
50	548.	84.6	160.8	1870.
100	733.	91.9	198.4	2710.
200	956.	100.4	236.9	3850.
500	1320.	113.3	288.4	6000.

METHOD: Combined methods 2 and 3
Flood frequency estimates for
Mathew Bird - US Graf
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	58.	71.5	20.0	169.
5	149.	67.3	54.0	410.
10	244.	69.4	86.2	691.
25	410.	75.2	135.0	1250.
50	574.	81.5	175.6	1880.
100	771.	88.6	218.0	2730.
200	1010.	96.9	261.1	3890.
500	1390.	109.3	319.1	6060.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - Sundance**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics and Active-channel width**
Drainage area in square miles:	**2.359949**
Percent basin above 6,000 feet:	**1.52**
Width of active channel in feet:	**6**

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
 Mathew Bird - Sundance
Upper Yellowstone-Central Mountain Region: A =      2.36 E6 =     2.
 RI        DISCHARGE  STD ERR OF                90% PRED. INTERVAL
             (cfs)      PREDICTION(%)
     2         13.        95.5                3.4                50.
     5         41.        73.5               13.9               123.
    10         74.        64.3               28.0               198.
    25        135.        58.3               55.1               332.
    50        197.        57.2               81.3               475.
   100        272.        58.2              111.0               667.
   200        366.        61.0              143.7               930.
   500        520.        66.9              189.7              1430.
```

```
 METHOD: Regression on active channel width
 Flood frequency estimates for
```

Mathew Bird - Sundance
Upper Yellowstone-Central Mountain Region: WAC = 6.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	37.	71.8	12.8	110.
5	103.	68.1	36.7	289.
10	175.	70.1	61.0	504.
25	304.	75.8	98.8	937.
50	434.	82.1	130.9	1440.
100	593.	89.3	165.1	2130.
200	788.	97.7	200.9	3090.
500	1110.	110.2	250.1	4920.

METHOD: Combined methods 1 and 2
Flood frequency estimates for
Mathew Bird - Sundance
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	28.	67.3	10.1	77.
5	69.	58.0	28.0	168.
10	108.	55.4	45.8	255.
25	170.	54.7	72.9	399.
50	227.	55.8	95.6	538.
100	293.	57.8	120.3	715.
200	373.	61.0	146.7	949.
500	520.	66.9	189.7	1430.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - Sundance**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics, Active-channel width, and Bankfull width**
Drainage area in square miles:	**2.359949**
Percent basin above 6,000 feet:	**1.52**
Width of active channel in feet:	**6**
Width of bank full channel in feet:	**12.5**

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
 Mathew Bird - Sundance
Upper Yellowstone-Central Mountain Region: A =      2.36 E6 =     2.
 RI       DISCHARGE  STD ERR OF              90% PRED. INTERVAL
            (cfs)      PREDICTION(%)
     2        13.        95.5              3.4              50.
     5        41.        73.5             13.9             123.
    10        74.        64.3             28.0             198.
    25       135.        58.3             55.1             332.
    50       197.        57.2             81.3             475.
   100       272.        58.2            111.0             667.
   200       366.        61.0            143.7             930.
   500       520.        66.9            189.7            1430.
```

METHOD: Regression on active channel width
Flood frequency estimates for
Mathew Bird - Sundance
Upper Yellowstone-Central Mountain Region: WAC = 6.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	37.	71.8	12.8	110.
5	103.	68.1	36.7	289.
10	175.	70.1	61.0	504.
25	304.	75.8	98.8	937.
50	434.	82.1	130.9	1440.
100	593.	89.3	165.1	2130.
200	788.	97.7	200.9	3090.
500	1110.	110.2	250.1	4920.

METHOD: Regression on bank full channel width
Flood frequency estimates for
Mathew Bird - Sundance
Upper Yellowstone-Central Mountain Region: WBF = 12.50

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	63.	159.5	9.6	411.
5	138.	72.3	46.7	407.
10	225.	73.2	75.5	672.
25	376.	78.4	118.3	1190.
50	524.	84.7	153.4	1790.
100	702.	92.0	189.9	2600.
200	918.	100.5	227.3	3710.
500	1270.	113.4	277.5	5790.

METHOD: Combined methods 1, 2 and 3
Flood frequency estimates for
Mathew Bird - Sundance
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	28.	67.3	10.1	77.
5	73.	53.1	32.0	167.
10	114.	52.2	50.4	257.
25	176.	53.3	76.6	403.
50	231.	55.3	98.1	545.
100	294.	57.7	120.8	716.
200	373.	61.0	146.7	949.
500	520.	66.9	189.7	1430.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - Sundance**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics and Bankfull width**
Drainage area in square miles:	**2.359949**
Percent basin above 6,000 feet:	**1.52**
Width of bank full channel in feet:	**12.5**

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
 Mathew Bird - Sundance
Upper Yellowstone-Central Mountain Region: A =      2.36 E6 =     2.
 RI        DISCHARGE  STD ERR OF                90% PRED. INTERVAL
             (cfs)      PREDICTION(%)
     2         13.        95.5                3.4                50.
     5         41.        73.5               13.9               123.
    10         74.        64.3               28.0               198.
    25        135.        58.3               55.1               332.
    50        197.        57.2               81.3               475.
   100        272.        58.2              111.0               667.
   200        366.        61.0              143.7               930.
   500        520.        66.9              189.7              1430.
```

```
 METHOD: Regression on bank full channel width
 Flood frequency estimates for
```

Mathew Bird - Sundance
Upper Yellowstone-Central Mountain Region: WBF = 12.50

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	63.	159.5	9.6	411.
5	138.	72.3	46.7	407.
10	225.	73.2	75.5	672.
25	376.	78.4	118.3	1190.
50	524.	84.7	153.4	1790.
100	702.	92.0	189.9	2600.
200	918.	100.5	227.3	3710.
500	1270.	113.4	277.5	5790.

METHOD: Combined methods 1 and 3
Flood frequency estimates for
Mathew Bird - Sundance
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	19.	89.6	5.2	67.
5	76.	58.6	31.0	188.
10	117.	55.5	49.7	277.
25	179.	54.7	76.5	418.
50	233.	55.8	98.3	553.
100	296.	57.9	121.5	723.
200	372.	61.0	146.4	947.
500	520.	66.9	189.7	1430.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - Sundance**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Active-channel width and Bankfull width**
Width of active channel in feet:	**6**
Width of bank full channel in feet:	**12.5**

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 active channel width
 Flood frequency estimates for
 Mathew Bird - Sundance
Upper Yellowstone-Central Mountain Region: WAC =      6.00
 RI       DISCHARGE  STD ERR OF              90% PRED. INTERVAL
            (cfs)      PREDICTION(%)
     2         37.        71.8              12.8              110.
     5        103.        68.1              36.7              289.
    10        175.        70.1              61.0              504.
    25        304.        75.8              98.8              937.
    50        434.        82.1             130.9             1440.
   100        593.        89.3             165.1             2130.
   200        788.        97.7             200.9             3090.
   500       1110.       110.2             250.1             4920.


 METHOD: Regression on bank full channel width
 Flood frequency estimates for
          Mathew Bird - Sundance
Upper Yellowstone-Central Mountain Region: WBF =     12.50
```

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	63.	159.5	9.6	411.
5	138.	72.3	46.7	407.
10	225.	73.2	75.5	672.
25	376.	78.4	118.3	1190.
50	524.	84.7	153.4	1790.
100	702.	92.0	189.9	2600.
200	918.	100.5	227.3	3710.
500	1270.	113.4	277.5	5790.

METHOD: Combined methods 2 and 3
Flood frequency estimates for
Mathew Bird - Sundance
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	37.	71.8	12.8	109.
5	111.	67.6	40.2	307.
10	186.	69.7	65.5	529.
25	316.	75.6	103.5	965.
50	443.	82.0	134.7	1460.
100	594.	89.3	166.7	2120.
200	788.	97.7	202.6	3070.
500	1110.	110.2	252.4	4870.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - Through Goldenstei**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics and Active-channel width**
Drainage area in square miles:	**2.194263**
Percent basin above 6,000 feet:	**1.63**
Width of active channel in feet:	**4**

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
 Mathew Bird - Through Goldenstei
Upper Yellowstone-Central Mountain Region: A =      2.19 E6 =     2.
 RI        DISCHARGE  STD ERR OF                90% PRED. INTERVAL
             (cfs)      PREDICTION(%)
     2         12.        95.6                3.2                47.
     5         39.        73.5               13.1               116.
    10         70.        64.4               26.4               187.
    25        127.        58.3               51.9               313.
    50        185.        57.2               76.5               448.
   100        256.        58.3              104.5               629.
   200        344.        61.1              135.2               876.
   500        490.        66.9              178.5              1340.
```

```
 METHOD: Regression on active channel width
 Flood frequency estimates for
```

Mathew Bird - Through Goldenstei
Upper Yellowstone-Central Mountain Region: WAC = 4.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	20.	72.5	6.8	60.
5	61.	68.8	21.5	172.
10	109.	70.8	37.5	316.
25	198.	76.7	63.7	617.
50	292.	83.1	87.0	979.
100	409.	90.5	112.5	1490.
200	557.	99.0	140.1	2220.
500	806.	111.8	179.1	3630.

METHOD: Combined methods 1 and 2
Flood frequency estimates for
Mathew Bird - Through Goldenstei
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	18.	67.7	6.3	49.
5	50.	58.4	20.3	122.
10	85.	55.6	35.8	201.
25	144.	54.9	61.4	338.
50	200.	55.9	84.2	476.
100	267.	57.9	109.3	652.
200	347.	61.0	136.4	884.
500	490.	66.9	178.5	1340.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - Through Goldenstei**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics, Active-channel width, and Bankfull width**
Drainage area in square miles:	**2.194263**
Percent basin above 6,000 feet:	**1.63**
Width of active channel in feet:	**4**
Width of bank full channel in feet:	**12**

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
 Mathew Bird - Through Goldenstei
Upper Yellowstone-Central Mountain Region: A =      2.19 E6 =     2.
 RI       DISCHARGE  STD ERR OF              90% PRED. INTERVAL
            (cfs)      PREDICTION(%)
     2        12.        95.6              3.2              47.
     5        39.        73.5             13.1             116.
    10        70.        64.4             26.4             187.
    25       127.        58.3             51.9             313.
    50       185.        57.2             76.5             448.
   100       256.        58.3            104.5             629.
   200       344.        61.1            135.2             876.
   500       490.        66.9            178.5            1340.
```

METHOD: Regression on active channel width
Flood frequency estimates for
Mathew Bird - Through Goldenstei
Upper Yellowstone-Central Mountain Region: WAC = 4.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	20.	72.5	6.8	60.
5	61.	68.8	21.5	172.
10	109.	70.8	37.5	316.
25	198.	76.7	63.7	617.
50	292.	83.1	87.0	979.
100	409.	90.5	112.5	1490.
200	557.	99.0	140.1	2220.
500	806.	111.8	179.1	3630.

METHOD: Regression on bank full channel width
Flood frequency estimates for
Mathew Bird - Through Goldenstei
Upper Yellowstone-Central Mountain Region: WBF = 12.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	58.	159.5	8.9	382.
5	130.	72.3	43.8	383.
10	213.	73.2	71.2	636.
25	357.	78.5	112.3	1140.
50	499.	84.8	146.1	1710.
100	671.	92.1	181.4	2490.
200	880.	100.7	217.7	3560.
500	1220.	113.6	266.6	5570.

METHOD: Combined methods 1, 2 and 3
Flood frequency estimates for
Mathew Bird - Through Goldenstei
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	18.	67.7	6.3	49.
5	60.	53.6	26.0	138.
10	99.	53.0	43.5	227.
25	162.	54.7	69.4	380.
50	220.	55.8	92.7	522.
100	279.	57.9	114.5	682.
200	351.	61.0	137.8	892.
500	490.	66.9	178.5	1340.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - Through Goldenstei**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Basin and Climatic Characteristics and Bankfull width**
Drainage area in square miles:	**2.194263**
Percent basin above 6,000 feet:	**1.63**
Width of bank full channel in feet:	**12**

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
 Mathew Bird - Through Goldenstei
Upper Yellowstone-Central Mountain Region: A =      2.19 E6 =     2.
 RI        DISCHARGE  STD ERR OF                90% PRED. INTERVAL
             (cfs)      PREDICTION(%)
     2         12.        95.6                3.2                47.
     5         39.        73.5               13.1               116.
    10         70.        64.4               26.4               187.
    25        127.        58.3               51.9               313.
    50        185.        57.2               76.5               448.
   100        256.        58.3              104.5               629.
   200        344.        61.1              135.2               876.
   500        490.        66.9              178.5              1340.
```

```
 METHOD: Regression on bank full channel width
 Flood frequency estimates for
```

Mathew Bird - Through Goldenstei
Upper Yellowstone-Central Mountain Region: WBF = 12.00

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	58.	159.5	8.9	382.
5	130.	72.3	43.8	383.
10	213.	73.2	71.2	636.
25	357.	78.5	112.3	1140.
50	499.	84.8	146.1	1710.
100	671.	92.1	181.4	2490.
200	880.	100.7	217.7	3560.
500	1220.	113.6	266.6	5570.

METHOD: Combined methods 1 and 3
Flood frequency estimates for
Mathew Bird - Through Goldenstei
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	18.	89.6	4.9	63.
5	72.	58.6	29.2	177.
10	111.	55.5	46.8	262.
25	169.	54.7	72.1	395.
50	220.	55.8	92.7	522.
100	279.	57.9	114.5	682.
200	351.	61.0	137.8	892.
500	490.	66.9	178.5	1340.

Montana Flood-Frequency and Basin-Characteristic Data

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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:	**Mathew Bird - Through Goldenstei**
Region:	**Upper Yellowstone**
Estimation method:	**Weighted estimate based on Active-channel width and Bankfull width**
Width of active channel in feet:	**4**
Width of bank full channel in feet:	**12**

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 active channel width
 Flood frequency estimates for
 Mathew Bird - Through Goldenstei
Upper Yellowstone-Central Mountain Region: WAC =      4.00
 RI       DISCHARGE  STD ERR OF              90% PRED. INTERVAL
            (cfs)      PREDICTION(%)
     2        20.        72.5              6.8              60.
     5        61.        68.8             21.5             172.
    10       109.        70.8             37.5             316.
    25       198.        76.7             63.7             617.
    50       292.        83.1             87.0             979.
   100       409.        90.5            112.5            1490.
   200       557.        99.0            140.1            2220.
   500       806.       111.8            179.1            3630.


 METHOD: Regression on bank full channel width
 Flood frequency estimates for
          Mathew Bird - Through Goldenstei
Upper Yellowstone-Central Mountain Region: WBF =     12.00
```

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	58.	159.5	8.9	382.
5	130.	72.3	43.8	383.
10	213.	73.2	71.2	636.
25	357.	78.5	112.3	1140.
50	499.	84.8	146.1	1710.
100	671.	92.1	181.4	2490.
200	880.	100.7	217.7	3560.
500	1220.	113.6	266.6	5570.

METHOD: Combined methods 2 and 3
Flood frequency estimates for
Mathew Bird - Through Goldenstei
Region 7

RI	DISCHARGE (cfs)	STD ERR OF PREDICTION(%)	90% PRED. INTERVAL	
2	20.	72.5	6.9	59.
5	76.	68.1	27.4	212.
10	133.	70.3	46.5	381.
25	234.	76.3	75.9	720.
50	335.	82.9	100.7	1110.
100	453.	90.3	125.7	1630.
200	597.	99.0	151.5	2350.
500	826.	111.8	185.2	3680.

Montana Flood-Frequency and Basin-Characteristic Data

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Mathew Bird Creek

Conversion of Rural Regression to Urban

Following procedures referenced in USGS WSP 2207 (Sauer et al)

At Mouth

	Regression								BDF	Channel Improvements	Channel Linings	Storm Drains	Curb and Gutter
			A	3.96									
	Rural	Urban	BDF	4	C	b1	b2	b3					
2		0			13.2	0.21	-0.43	0.73	Lower	1	0	1	1
5		0			10.6	0.17	-0.39	0.78	Middle	0	0	0	1
10	113	225			9.51	0.16	-0.36	0.79	Upper	0	0	0	0
25	206	359			8.68	0.15	-0.34	0.8					
50	299	495			8.04	0.15	-0.32	0.81					
100	415	657			7.7	0.15	-0.32	0.82					
500	794	1149			7.47	0.16	-0.3	0.82					

Upstream Garfield Street

	Regression												
			A	3.80									
	Rural	Urban	BDF	4	C	b1	b2	b3					
2		0			13.2	0.21	-0.43	0.73	Lower	1	0	1	1
5		0			10.6	0.17	-0.39	0.78	Middle	0	0	0	1
10	110	220			9.51	0.16	-0.36	0.79	Upper	0	0	0	0
25	200	350			8.68	0.15	-0.34	0.8					
50	290	483			8.04	0.15	-0.32	0.81					
100	402	640			7.7	0.15	-0.32	0.82					
500	771	1122			7.47	0.16	-0.3	0.82					

Upstream Figgins Creek

	Regression												
			A	2.74									
	Rural	Urban	BDF	3	C	b1	b2	b3					
2		0			13.2	0.21	-0.43	0.73	Lower	1	0	1	1
5		0			10.6	0.17	-0.39	0.78	Middle	0	0	0	0
10	84	178			9.51	0.16	-0.36	0.79	Upper	0	0	0	0
25	153	283			8.68	0.15	-0.34	0.8					
50	222	389			8.04	0.15	-0.32	0.81					
100	307	513			7.7	0.15	-0.32	0.82					
500	589	900			7.47	0.16	-0.3	0.82					

Upstream Graf Street

	Regression												
			A	2.58									
	Rural	Urban	BDF	0	C	b1	b2	b3					
2		0			13.2	0.21	-0.43	0.73	Lower	0	0	0	0
5		0			10.6	0.17	-0.39	0.78	Middle	0	0	0	0
10	80	171			9.51	0.16	-0.36	0.79	Upper	0	0	0	0
25	145	271			8.68	0.15	-0.34	0.8					
50	211	373			8.04	0.15	-0.32	0.81					
100	293	494			7.7	0.15	-0.32	0.82					
500	560	863			7.47	0.16	-0.3	0.82					

Near Sundance Drive

	Regression												
			A	2.36									
	Rural	Urban	BDF	0	C	b1	b2	b3					
2		0			13.2	0.21	-0.43	0.73	Lower	0	0	0	0
5		0			10.6	0.17	-0.39	0.78	Middle	0	0	0	0
10	74	161			9.51	0.16	-0.36	0.79	Upper	0	0	0	0
25	135	256			8.68	0.15	-0.34	0.8					
50	197	353			8.04	0.15	-0.32	0.81					
100	272	465			7.7	0.15	-0.32	0.82					
500	520	812			7.47	0.16	-0.3	0.82					

Through Goldenstein Lane

	Regression												
			A	2.19									
	Rural	Urban	BDF	0	C	b1	b2	b3					
2		0			13.2	0.21	-0.43	0.73	Lower	0	0	0	0
5		0			10.6	0.17	-0.39	0.78	Middle	0	0	0	0
10	70	154			9.51	0.16	-0.36	0.79	Upper	0	0	0	0
25	127	244			8.68	0.15	-0.34	0.8					
50	185	336			8.04	0.15	-0.32	0.81					
100	256	442			7.7	0.15	-0.32	0.82					
500	490	774			7.47	0.16	-0.3	0.82					

Appendix B. 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*

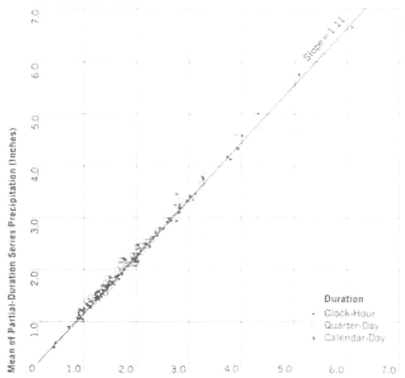
Values interpolated using Figure 17 of *Precipitation-Frequency Atlas of the Western United States, Volume I - Montana*

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.*



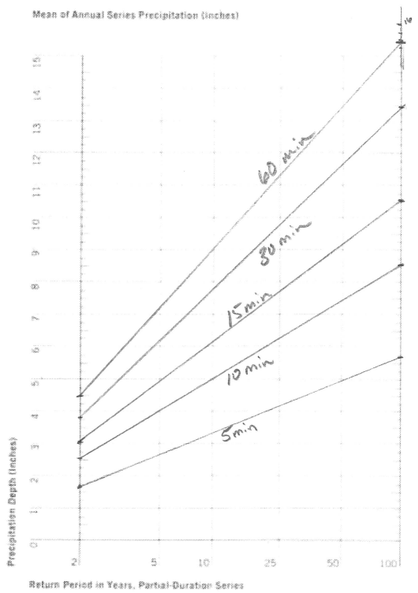
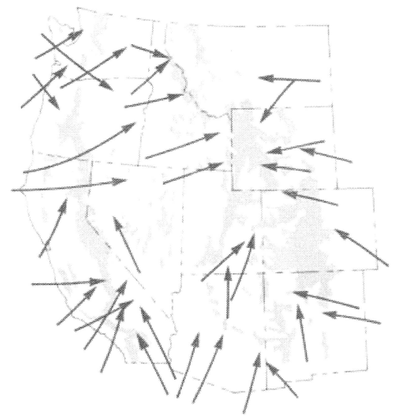


Figure 6. *Precipitation depth versus return period for partial-duration series.*

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.

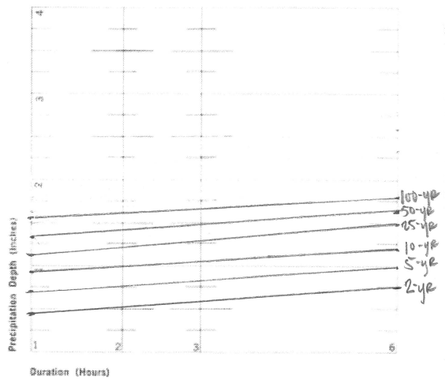
Although the computer program treated each variable as linear during the regression analysis, it was possible through internal computations to use logarithms, powers, roots, reciprocals, or combinations of any or all of the factors. The computer program selected the single variable most highly correlated 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).*



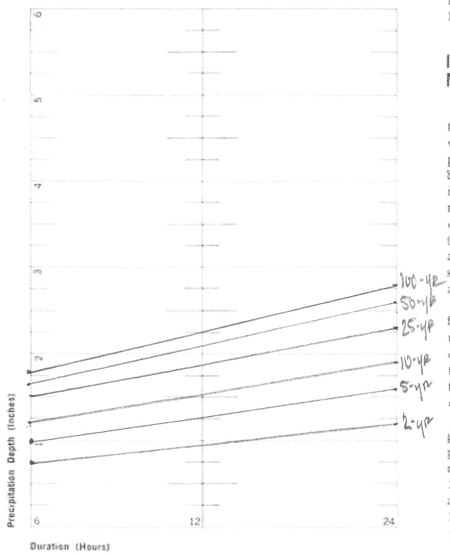


Figure 17. *Precipitation depth-duration diagram (6 to 24 hrs).*

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.

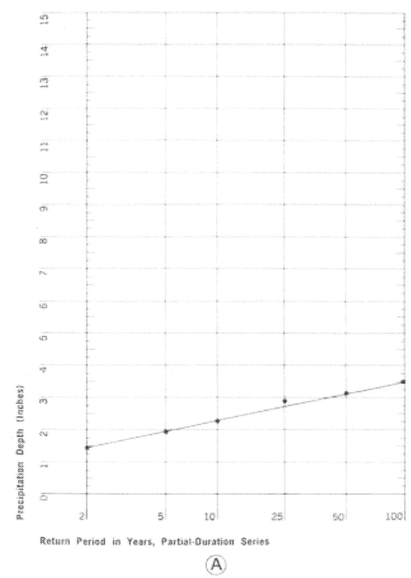
Table 11. *Adjustment factors to obtain n-minute estimates from 1-hr values*

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**



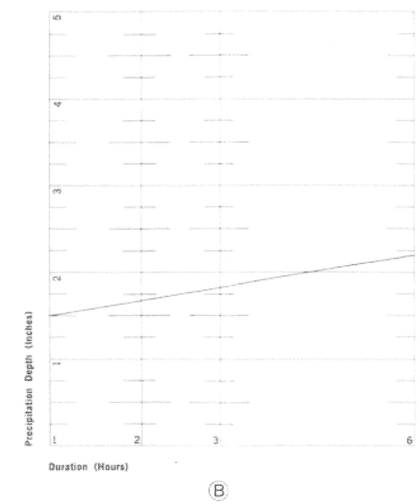


Figure 18. *Illustration of use of precipitation-frequency diagrams using values from precipitation-frequency maps and relations at 47°00′ N., 110°00′ W.*

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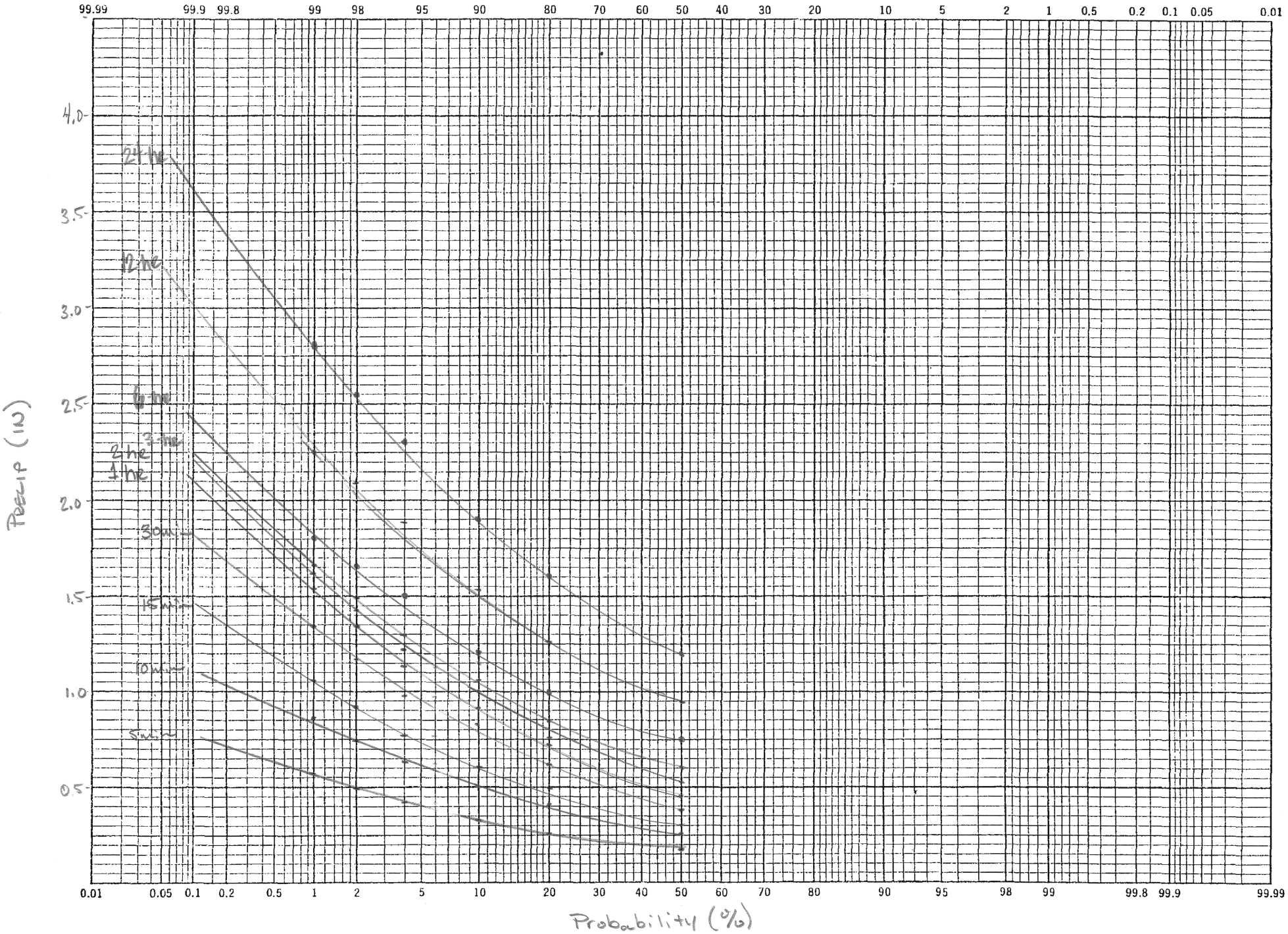

Appendix C. Curve Number Look-Up Table

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)	
Herbaceuous		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	89	92	94	95	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)	

Land Use Category	Hydrologic Soil Group				Description	Assumption	Reference	Source
	A	B	C	D				
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)	CI
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.	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)	Based upon Bozeman City aerial, UDV areas of Mathew Bird/Figgins Creek watersheds 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 D. 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
FW100-1	Developed, Medium Intensity	C	83.0	0.0001	0.0113	0.95%	1.0%	0.8	0.8	
FW100-1	Hay/Pasture	C	74.0	0.0009	0.0113	8.42%	9.4%	6.2	7.0	
FW100-1	Hay/Pasture	C	74.0	0.0042	0.0113	37.68%	47.1%	27.9	34.9	
FW100-1	MFR	C	90.0	0.0002	0.0113	1.74%	48.8%	1.6	36.5	
FW100-1	Hay/Pasture	D	80.0	0.0058	0.0113	51.05%	99.8%	40.8	77.3	
FW100-1	MFR	D	92.0	0.0000	0.0113	0.15%	100.0%	0.1	77.5	**77.5**
FW1370-1	CHURCH	C	94.0	0.0010	0.0378	2.58%	2.6%	2.4	2.4	
FW1370-1	POS	C	74.0	0.0015	0.0378	4.09%	6.7%	3.0	5.4	
FW1370-1	ROW	C	98.0	0.0101	0.0378	26.74%	33.4%	26.2	31.7	
FW1370-1	SFR	C	83.0	0.0001	0.0378	0.27%	33.7%	0.2	31.9	
FW1370-1	SFR	C	83.0	0.0009	0.0378	2.26%	35.9%	1.9	33.8	
FW1370-1	SFR	C	83.0	0.0028	0.0378	7.33%	43.3%	6.1	39.8	
FW1370-1	SFR	C	83.0	0.0098	0.0378	25.89%	69.2%	21.5	61.3	
FW1370-1	SFR	C	83.0	0.0115	0.0378	30.59%	99.7%	25.4	86.7	
FW1370-1	VACANT	C	91.0	0.0001	0.0378	0.26%	100.0%	0.2	86.9	**86.9**
FW1520-1	CHURCH	C	94.0	0.0031	0.0448	7.00%	7.0%	6.6	6.6	
FW1520-1	CHURCH	C	94.0	0.0063	0.0448	13.99%	21.0%	13.2	19.7	
FW1520-1	Developed, Open Space	C	74.0	0.0018	0.0448	3.91%	24.9%	2.9	22.6	
FW1520-1	POS	C	74.0	0.0021	0.0448	4.77%	29.7%	3.5	26.2	
FW1520-1	ROW	C	98.0	0.0094	0.0448	20.90%	50.6%	20.5	46.6	
FW1520-1	SFR	C	83.0	0.0003	0.0448	0.68%	51.3%	0.6	47.2	
FW1520-1	SFR	C	83.0	0.0014	0.0448	3.14%	54.4%	2.6	49.8	
FW1520-1	SFR	C	83.0	0.0023	0.0448	5.08%	59.5%	4.2	54.0	
FW1520-1	SFR	C	83.0	0.0029	0.0448	6.40%	65.9%	5.3	59.3	
FW1520-1	SFR	C	83.0	0.0036	0.0448	8.12%	74.0%	6.7	66.1	
FW1520-1	SFR	C	83.0	0.0046	0.0448	10.32%	84.3%	8.6	74.6	
FW1520-1	SFR	C	83.0	0.0070	0.0448	15.69%	100.0%	13.0	87.7	**87.7**
FW1700-1	MFR	C	90.0	0.0000	0.0005	2.49%	2.5%	2.2	2.2	
FW1700-1	MIXED	C	84.0	0.0000	0.0005	0.39%	2.9%	0.3	2.6	
FW1700-1	ROW	C	98.0	0.0005	0.0005	97.12%	100.0%	95.2	97.7	**97.7**
FW170-1	Developed, Low Intensity	C	80.0	0.0000	0.0051	0.01%	0.0%	0.0	0.0	
FW170-1	Developed, Low Intensity	C	80.0	0.0000	0.0051	0.05%	0.1%	0.0	0.0	
FW170-1	Developed, Low Intensity	C	80.0	0.0000	0.0051	0.61%	0.7%	0.5	0.5	
FW170-1	Developed, Medium Intensity	C	83.0	0.0001	0.0051	1.58%	2.2%	1.3	1.8	
FW170-1	Hay/Pasture	C	74.0	0.0001	0.0051	1.44%	3.7%	1.1	2.9	
FW170-1	Hay/Pasture	C	74.0	0.0035	0.0051	68.14%	71.8%	50.4	53.3	
FW170-1	POS	C	74.0	0.0000	0.0051	0.06%	71.9%	0.0	53.4	
FW170-1	ROW	C	98.0	0.0000	0.0051	0.29%	72.2%	0.3	53.7	
FW170-1	ROW	C	98.0	0.0000	0.0051	0.44%	72.6%	0.4	54.1	
FW170-1	Developed, Low Intensity	D	85.0	0.0002	0.0051	4.69%	77.3%	4.0	58.1	
FW170-1	Hay/Pasture	D	80.0	0.0011	0.0051	21.90%	99.2%	17.5	75.6	
FW170-1	ROW	D	98.0	0.0000	0.0051	0.79%	100.0%	0.8	76.4	**76.4**
FW1720-1	ROW	C	98.0	0.0020	0.0043	46.81%	46.8%	45.9	45.9	
FW1720-1	SFR	C	83.0	0.0011	0.0043	24.52%	71.3%	20.4	66.2	
FW1720-1	SFR	C	83.0	0.0012	0.0043	28.67%	100.0%	23.8	90.0	**90.0**
FW1800-1	AP	C	90.0	0.0000	0.0213	0.00%	0.0%	0.0	0.0	
FW1800-1	Developed, Low Intensity	C	80.0	0.0000	0.0213	0.00%	0.0%	0.0	0.0	
FW1800-1	Developed, Low Intensity	C	80.0	0.0000	0.0213	0.12%	0.1%	0.1	0.1	
FW1800-1	Hay/Pasture	C	74.0	0.0001	0.0213	0.29%	0.4%	0.2	0.3	
FW1800-1	MIXED	C	84.0	0.0001	0.0213	0.46%	0.9%	0.4	0.7	
FW1800-1	MIXED	C	84.0	0.0001	0.0213	0.66%	1.5%	0.6	1.3	
FW1800-1	MIXED	C	84.0	0.0008	0.0213	3.67%	5.2%	3.1	4.3	
FW1800-1	POS	C	74.0	0.0001	0.0213	0.51%	5.7%	0.4	4.7	
FW1800-1	POS	C	74.0	0.0089	0.0213	41.69%	47.4%	30.8	35.6	
FW1800-1	ROW	C	98.0	0.0010	0.0213	4.61%	52.0%	4.5	40.1	
FW1800-1	ROW	C	98.0	0.0039	0.0213	18.55%	70.6%	18.2	58.3	
FW1800-1	SEF	C	86.0	0.0000	0.0213	0.06%	70.6%	0.0	58.3	

Basin	Comp CN
FW100-1	77.5
FW1370-1	86.9
FW1520-1	87.7
FW1700-1	97.7
FW170-1	76.4
FW1720-1	90.0
FW1800-1	84.4
FW1850-1	83.3
FW1900-1	78.3
FW1950-1	78.2
FW2160-1	80.8
FW220-1	85.5
FW260-1	90.5
FW2800-1	82.4
FW330-1	75.5
FW430-1	79.9
FW470-1	76.9
FW630-1	75.7
FW710-1	86.2
FW760-1	85.9
FW770-1	83.6
FW820-1	75.4
FW860-1	81.8
FW960-1	82.0
W1340	68.5
W180	83.7
W210	78.8
W211	79.0
W220	87.7
W221	80.2
W250	70.1
W251	68.9
W260	78.2
W270	71.1
W280	75.0
W290	75.1
W300	69.1
W320	84.7
W370	81.5
W380	84.5

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
FW1800-1	SEF	C	86.0	0.0039	0.0213	18.51%	89.1%	15.9	74.2	
FW1800-1	AP	D	92.0	0.0000	0.0213	0.13%	89.3%	0.1	74.3	
FW1800-1	MIXED	D	88.0	0.0010	0.0213	4.67%	93.9%	4.1	78.5	
FW1800-1	RB	D	95.0	0.0000	0.0213	0.04%	94.0%	0.0	78.5	
FW1800-1	ROW	D	98.0	0.0003	0.0213	1.44%	95.4%	1.4	79.9	
FW1800-1	ROW	D	98.0	0.0010	0.0213	4.60%	100.0%	4.5	84.4	**84.4**
FW1850-1	Cultivated Crops	C	81.0	0.0067	0.0208	32.36%	32.4%	26.2	26.2	
FW1850-1	Developed, Low Intensity	C	80.0	0.0000	0.0208	0.02%	32.4%	0.0	26.2	
FW1850-1	Developed, Medium Intensity	C	83.0	0.0002	0.0208	0.85%	33.2%	0.7	26.9	
FW1850-1	Hay/Pasture	C	74.0	0.0009	0.0208	4.39%	37.6%	3.2	30.2	
FW1850-1	POS	C	74.0	0.0000	0.0208	0.01%	37.6%	0.0	30.2	
FW1850-1	POS	C	74.0	0.0009	0.0208	4.42%	42.0%	3.3	33.5	
FW1850-1	ROW	C	98.0	0.0000	0.0208	0.07%	42.1%	0.1	33.5	
FW1850-1	SEF	C	86.0	0.0121	0.0208	57.89%	100.0%	49.8	83.3	**83.3**
FW1900-1	Cultivated Crops	C	81.0	0.0000	0.0218	0.01%	0.0%	0.0	0.0	
FW1900-1	Cultivated Crops	C	81.0	0.0134	0.0218	61.65%	61.7%	49.9	49.9	
FW1900-1	Hay/Pasture	C	74.0	0.0008	0.0218	3.55%	65.2%	2.6	52.6	
FW1900-1	Hay/Pasture	C	74.0	0.0045	0.0218	20.75%	86.0%	15.4	67.9	
FW1900-1	Herbaceuous	C	74.0	0.0001	0.0218	0.55%	86.5%	0.4	68.3	
FW1900-1	Herbaceuous	C	74.0	0.0026	0.0218	12.13%	98.6%	9.0	77.3	
FW1900-1	POS	C	74.0	0.0003	0.0218	1.36%	100.0%	1.0	78.3	**78.3**
FW1950-1	Cultivated Crops	C	81.0	0.0056	0.1364	4.09%	4.1%	3.3	3.3	
FW1950-1	Cultivated Crops	C	81.0	0.0273	0.1364	20.03%	24.1%	16.2	19.5	
FW1950-1	Developed, Low Intensity	C	80.0	0.0002	0.1364	0.18%	24.3%	0.1	19.7	
FW1950-1	Developed, Open Space	C	74.0	0.0000	0.1364	0.00%	24.3%	0.0	19.7	
FW1950-1	Developed, Open Space	C	74.0	0.0000	0.1364	0.02%	24.3%	0.0	19.7	
FW1950-1	Developed, Open Space	C	74.0	0.0000	0.1364	0.03%	24.4%	0.0	19.7	
FW1950-1	Developed, Open Space	C	74.0	0.0002	0.1364	0.18%	24.5%	0.1	19.9	
FW1950-1	Developed, Open Space	C	74.0	0.0003	0.1364	0.20%	24.7%	0.2	20.0	
FW1950-1	Developed, Open Space	C	74.0	0.0004	0.1364	0.30%	25.1%	0.2	20.2	
FW1950-1	Developed, Open Space	C	74.0	0.0019	0.1364	1.36%	26.4%	1.0	21.2	
FW1950-1	Hay/Pasture	C	74.0	0.0003	0.1364	0.24%	26.7%	0.2	21.4	
FW1950-1	Hay/Pasture	C	74.0	0.0612	0.1364	44.89%	71.5%	33.2	54.6	
FW1950-1	Herbaceuous	C	74.0	0.0001	0.1364	0.09%	71.6%	0.1	54.7	
FW1950-1	POS	C	74.0	0.0001	0.1364	0.08%	71.7%	0.1	54.8	
FW1950-1	POS	C	74.0	0.0018	0.1364	1.34%	73.0%	1.0	55.8	
FW1950-1	POS	C	74.0	0.0097	0.1364	7.12%	80.2%	5.3	61.0	
FW1950-1	ROW	C	98.0	0.0046	0.1364	3.39%	83.6%	3.3	64.3	
FW1950-1	SEF	C	86.0	0.0093	0.1364	6.85%	90.4%	5.9	70.2	
FW1950-1	SFR	C	83.0	0.0000	0.1364	0.00%	90.4%	0.0	70.2	
FW1950-1	SFR	C	83.0	0.0000	0.1364	0.01%	90.4%	0.0	70.3	
FW1950-1	SFR	C	83.0	0.0005	0.1364	0.34%	90.8%	0.3	70.5	
FW1950-1	SFR	C	83.0	0.0006	0.1364	0.44%	91.2%	0.4	70.9	
FW1950-1	SFR	C	83.0	0.0048	0.1364	3.54%	94.7%	2.9	73.8	
FW1950-1	SFR	C	83.0	0.0052	0.1364	3.78%	98.5%	3.1	77.0	
FW1950-1	UDV	C	83.0	0.0011	0.1364	0.84%	99.4%	0.7	77.7	
FW1950-1	VACANT	C	91.0	0.0001	0.1364	0.08%	99.4%	0.1	77.7	
FW1950-1	VACANT	C	91.0	0.0003	0.1364	0.23%	99.7%	0.2	78.0	
FW1950-1	VACANT	C	91.0	0.0004	0.1364	0.32%	100.0%	0.3	78.2	**78.2**
FW2160-1	Cultivated Crops	C	81.0	0.0111	0.0139	79.99%	80.0%	64.8	64.8	
FW2160-1	Hay/Pasture	C	74.0	0.0008	0.0139	5.63%	85.6%	4.2	69.0	
FW2160-1	Hay/Pasture	C	74.0	0.0009	0.0139	6.23%	91.8%	4.6	73.6	
FW2160-1	POS	C	74.0	0.0000	0.0139	0.17%	92.0%	0.1	73.7	
FW2160-1	ROW	C	98.0	0.0004	0.0139	3.00%	95.0%	2.9	76.6	
FW2160-1	SFR	C	83.0	0.0001	0.0139	1.00%	96.0%	0.8	77.5	
FW2160-1	SFR	C	83.0	0.0006	0.0139	3.99%	100.0%	3.3	80.8	**80.8**
FW220-1	Developed, Low Intensity	C	80.0	0.0000	0.0111	0.00%	0.0%	0.0	0.0	

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
FW220-1	Hay/Pasture	C	74.0	0.0000	0.0111	0.00%	0.0%	0.0	0.0	
FW220-1	MIXED	C	84.0	0.0001	0.0111	0.65%	0.7%	0.5	0.6	
FW220-1	MIXED	C	84.0	0.0045	0.0111	40.86%	41.5%	34.3	34.9	
FW220-1	ROW	C	98.0	0.0000	0.0111	0.02%	41.5%	0.0	34.9	
FW220-1	ROW	C	98.0	0.0010	0.0111	9.27%	50.8%	9.1	44.0	
FW220-1	SFR	C	83.0	0.0040	0.0111	36.37%	87.2%	30.2	74.2	
FW220-1	VACANT	C	91.0	0.0002	0.0111	1.44%	88.6%	1.3	75.5	
FW220-1	MIXED	D	88.0	0.0012	0.0111	11.27%	99.9%	9.9	85.4	
FW220-1	ROW	D	98.0	0.0000	0.0111	0.12%	100.0%	0.1	85.5	**85.5**
FW260-1	DTR	C	90.0	0.0000	0.0028	0.78%	0.8%	0.7	0.7	
FW260-1	MFR	C	90.0	0.0026	0.0028	93.05%	93.8%	83.7	84.4	
FW260-1	ROW	C	98.0	0.0002	0.0028	6.17%	100.0%	6.0	90.5	**90.5**
FW2800-1	Cultivated Crops	C	81.0	0.0035	0.1379	2.57%	2.6%	2.1	2.1	
FW2800-1	Developed, Low Intensity	C	80.0	0.0000	0.1379	0.02%	2.6%	0.0	2.1	
FW2800-1	Developed, Medium Intensity	C	83.0	0.0003	0.1379	0.21%	2.8%	0.2	2.3	
FW2800-1	Developed, Open Space	C	74.0	0.0002	0.1379	0.15%	3.0%	0.1	2.4	
FW2800-1	Developed, Open Space	C	74.0	0.0013	0.1379	0.94%	3.9%	0.7	3.1	
FW2800-1	Hay/Pasture	C	74.0	0.0437	0.1379	31.71%	35.6%	23.5	26.5	
FW2800-1	POS	C	74.0	0.0000	0.1379	0.00%	35.6%	0.0	26.5	
FW2800-1	POS	C	74.0	0.0000	0.1379	0.03%	35.6%	0.0	26.6	
FW2800-1	POS	C	74.0	0.0002	0.1379	0.14%	35.8%	0.1	26.7	
FW2800-1	POS	C	74.0	0.0009	0.1379	0.67%	36.4%	0.5	27.2	
FW2800-1	POS	C	74.0	0.0010	0.1379	0.73%	37.2%	0.5	27.7	
FW2800-1	POS	C	74.0	0.0011	0.1379	0.81%	38.0%	0.6	28.3	
FW2800-1	ROW	C	98.0	0.0006	0.1379	0.42%	38.4%	0.4	28.7	
FW2800-1	ROW	C	98.0	0.0185	0.1379	13.43%	51.8%	13.2	41.9	
FW2800-1	SEF	C	86.0	0.0084	0.1379	6.07%	57.9%	5.2	47.1	
FW2800-1	SEF	C	86.0	0.0138	0.1379	10.00%	67.9%	8.6	55.7	
FW2800-1	SFR	C	83.0	0.0000	0.1379	0.02%	67.9%	0.0	55.7	
FW2800-1	SFR	C	83.0	0.0002	0.1379	0.14%	68.0%	0.1	55.8	
FW2800-1	SFR	C	83.0	0.0003	0.1379	0.22%	68.3%	0.2	56.0	
FW2800-1	SFR	C	83.0	0.0003	0.1379	0.23%	68.5%	0.2	56.2	
FW2800-1	SFR	C	83.0	0.0006	0.1379	0.40%	68.9%	0.3	56.5	
FW2800-1	SFR	C	83.0	0.0008	0.1379	0.59%	69.5%	0.5	57.0	
FW2800-1	SFR	C	83.0	0.0012	0.1379	0.84%	70.3%	0.7	57.7	
FW2800-1	SFR	C	83.0	0.0012	0.1379	0.84%	71.2%	0.7	58.4	
FW2800-1	SFR	C	83.0	0.0020	0.1379	1.46%	72.6%	1.2	59.6	
FW2800-1	SFR	C	83.0	0.0044	0.1379	3.17%	75.8%	2.6	62.3	
FW2800-1	SFR	C	83.0	0.0044	0.1379	3.20%	79.0%	2.7	64.9	
FW2800-1	SFR	C	83.0	0.0048	0.1379	3.44%	82.5%	2.9	67.8	
FW2800-1	SFR	C	83.0	0.0051	0.1379	3.68%	86.1%	3.1	70.8	
FW2800-1	SFR	C	83.0	0.0051	0.1379	3.72%	89.9%	3.1	73.9	
FW2800-1	VACANT	C	91.0	0.0003	0.1379	0.21%	90.1%	0.2	74.1	
FW2800-1	VACANT	C	91.0	0.0003	0.1379	0.23%	90.3%	0.2	74.3	
FW2800-1	VACANT	C	91.0	0.0003	0.1379	0.24%	90.6%	0.2	74.6	
FW2800-1	VACANT	C	91.0	0.0007	0.1379	0.47%	91.0%	0.4	75.0	
FW2800-1	VACANT	C	91.0	0.0011	0.1379	0.82%	91.8%	0.7	75.7	
FW2800-1	Developed, Low Intensity	D	85.0	0.0000	0.1379	0.03%	91.9%	0.0	75.8	
FW2800-1	Hay/Pasture	D	80.0	0.0000	0.1379	0.01%	91.9%	0.0	75.8	
FW2800-1	POS	D	80.0	0.0046	0.1379	3.33%	95.2%	2.7	78.4	
FW2800-1	POS	D	80.0	0.0050	0.1379	3.63%	98.8%	2.9	81.3	
FW2800-1	ROW	D	98.0	0.0002	0.1379	0.12%	99.0%	0.1	81.5	
FW2800-1	SEF	D	89.0	0.0006	0.1379	0.46%	99.4%	0.4	81.9	
FW2800-1	SFR	D	87.0	0.0008	0.1379	0.58%	100.0%	0.5	82.4	**82.4**
FW330-1	Cultivated Crops	C	81.0	0.0002	0.0335	0.70%	0.7%	0.6	0.6	
FW330-1	Cultivated Crops	C	81.0	0.0002	0.0335	0.71%	1.4%	0.6	1.1	
FW330-1	Cultivated Crops	C	81.0	0.0004	0.0335	1.11%	2.5%	0.9	2.0	

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FW330-1	Cultivated Crops	C	81.0	0.0065	0.0335	19.44%	22.0%	15.7	17.8	
FW330-1	Hay/Pasture	C	74.0	0.0000	0.0335	0.03%	22.0%	0.0	17.8	
FW330-1	Hay/Pasture	C	74.0	0.0093	0.0335	27.61%	49.6%	20.4	38.2	
FW330-1	POS	C	74.0	0.0169	0.0335	50.39%	100.0%	37.3	75.5	**75.5**
FW430-1	Cultivated Crops	C	81.0	0.0057	0.0089	63.55%	63.6%	51.5	51.5	
FW430-1	Hay/Pasture	C	74.0	0.0002	0.0089	2.30%	65.9%	1.7	53.2	
FW430-1	Hay/Pasture	C	74.0	0.0004	0.0089	4.40%	70.3%	3.3	56.4	
FW430-1	POS	C	74.0	0.0002	0.0089	2.56%	72.8%	1.9	58.3	
FW430-1	POS	C	74.0	0.0012	0.0089	13.01%	85.8%	9.6	68.0	
FW430-1	ROW	C	98.0	0.0001	0.0089	0.60%	86.4%	0.6	68.6	
FW430-1	ROW	C	98.0	0.0001	0.0089	0.62%	87.1%	0.6	69.2	
FW430-1	SFR	C	83.0	0.0000	0.0089	0.06%	87.1%	0.1	69.2	
FW430-1	SFR	C	83.0	0.0002	0.0089	2.15%	89.3%	1.8	71.0	
FW430-1	SFR	C	83.0	0.0010	0.0089	10.74%	100.0%	8.9	79.9	**79.9**
FW470-1	Cultivated Crops	C	81.0	0.0047	0.0546	8.56%	8.6%	6.9	6.9	
FW470-1	Cultivated Crops	C	81.0	0.0176	0.0546	32.24%	40.8%	26.1	33.0	
FW470-1	Developed, Open Space	C	74.0	0.0019	0.0546	3.47%	44.3%	2.6	35.6	
FW470-1	Hay/Pasture	C	74.0	0.0304	0.0546	55.74%	100.0%	41.2	76.9	**76.9**
FW630-1	Cultivated Crops	C	81.0	0.0032	0.0396	8.09%	8.1%	6.6	6.6	
FW630-1	Cultivated Crops	C	81.0	0.0064	0.0396	16.13%	24.2%	13.1	19.6	
FW630-1	Hay/Pasture	C	74.0	0.0300	0.0396	75.76%	100.0%	56.1	75.7	
FW630-1	POS	C	74.0	0.0000	0.0396	0.01%	100.0%	0.0	75.7	**75.7**
FW710-1	Developed, Low Intensity	C	80.0	0.0010	0.0507	1.90%	1.9%	1.5	1.5	
FW710-1	Developed, Medium Intensity	C	83.0	0.0003	0.0507	0.66%	2.6%	0.5	2.1	
FW710-1	Developed, Open Space	C	74.0	0.0009	0.0507	1.82%	4.4%	1.3	3.4	
FW710-1	Hay/Pasture	C	74.0	0.0000	0.0507	0.00%	4.4%	0.0	3.4	
FW710-1	MFR	C	90.0	0.0000	0.0507	0.01%	4.4%	0.0	3.4	
FW710-1	MFR	C	90.0	0.0000	0.0507	0.04%	4.4%	0.0	3.5	
FW710-1	MFR	C	90.0	0.0015	0.0507	2.90%	7.3%	2.6	6.1	
FW710-1	POS	C	74.0	0.0021	0.0507	4.05%	11.4%	3.0	9.1	
FW710-1	ROW	C	98.0	0.0001	0.0507	0.22%	11.6%	0.2	9.3	
FW710-1	ROW	C	98.0	0.0092	0.0507	18.10%	29.7%	17.7	27.0	
FW710-1	SEF	C	86.0	0.0001	0.0507	0.20%	29.9%	0.2	27.2	
FW710-1	SFR	C	83.0	0.0001	0.0507	0.19%	30.1%	0.2	27.3	
FW710-1	SFR	C	83.0	0.0001	0.0507	0.22%	30.3%	0.2	27.5	
FW710-1	SFR	C	83.0	0.0009	0.0507	1.79%	32.1%	1.5	29.0	
FW710-1	SFR	C	83.0	0.0016	0.0507	3.06%	35.2%	2.5	31.5	
FW710-1	SFR	C	83.0	0.0051	0.0507	10.02%	45.2%	8.3	39.9	
FW710-1	SFR	C	83.0	0.0073	0.0507	14.32%	59.5%	11.9	51.7	
FW710-1	SFR	C	83.0	0.0108	0.0507	21.38%	80.9%	17.7	69.5	
FW710-1	AP	D	92.0	0.0001	0.0507	0.19%	81.1%	0.2	69.7	
FW710-1	Developed, Low Intensity	D	85.0	0.0000	0.0507	0.01%	81.1%	0.0	69.7	
FW710-1	Developed, Low Intensity	D	85.0	0.0002	0.0507	0.46%	81.5%	0.4	70.1	
FW710-1	Developed, Open Space	D	80.0	0.0007	0.0507	1.40%	82.9%	1.1	71.2	
FW710-1	Hay/Pasture	D	80.0	0.0000	0.0507	0.01%	82.9%	0.0	71.2	
FW710-1	Hay/Pasture	D	80.0	0.0012	0.0507	2.46%	85.4%	2.0	73.2	
FW710-1	MFR	D	92.0	0.0034	0.0507	6.63%	92.0%	6.1	79.3	
FW710-1	POS	D	80.0	0.0001	0.0507	0.18%	92.2%	0.1	79.4	
FW710-1	POS	D	80.0	0.0002	0.0507	0.30%	92.5%	0.2	79.6	
FW710-1	ROW	D	98.0	0.0000	0.0507	0.00%	92.5%	0.0	79.6	
FW710-1	ROW	D	98.0	0.0002	0.0507	0.46%	93.0%	0.5	80.1	
FW710-1	SFR	D	87.0	0.0000	0.0507	0.00%	93.0%	0.0	80.1	
FW710-1	SFR	D	87.0	0.0002	0.0507	0.44%	93.4%	0.4	80.5	
FW710-1	SFR	D	87.0	0.0033	0.0507	6.60%	100.0%	5.7	86.2	**86.2**
FW760-1	Developed, Low Intensity	C	80.0	0.0000	0.0802	0.00%	0.0%	0.0	0.0	
FW760-1	Developed, Low Intensity	C	80.0	0.0000	0.0802	0.05%	0.1%	0.0	0.0	
FW760-1	Developed, Low Intensity	C	80.0	0.0003	0.0802	0.32%	0.4%	0.3	0.3	

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FW760-1	Developed, Open Space	C	74.0	0.0039	0.0802	4.83%	5.2%	3.6	3.9	
FW760-1	Hay/Pasture	C	74.0	0.0046	0.0802	5.69%	10.9%	4.2	8.1	
FW760-1	MFR	C	90.0	0.0006	0.0802	0.69%	11.6%	0.6	8.7	
FW760-1	POS	C	74.0	0.0009	0.0802	1.12%	12.7%	0.8	9.5	
FW760-1	ROW	C	98.0	0.0212	0.0802	26.39%	39.1%	25.9	35.4	
FW760-1	SFR	C	83.0	0.0000	0.0802	0.01%	39.1%	0.0	35.4	
FW760-1	SFR	C	83.0	0.0009	0.0802	1.08%	40.2%	0.9	36.3	
FW760-1	SFR	C	83.0	0.0022	0.0802	2.78%	43.0%	2.3	38.6	
FW760-1	SFR	C	83.0	0.0041	0.0802	5.06%	48.0%	4.2	42.8	
FW760-1	SFR	C	83.0	0.0043	0.0802	5.36%	53.4%	4.5	47.2	
FW760-1	SFR	C	83.0	0.0075	0.0802	9.31%	62.7%	7.7	55.0	
FW760-1	SFR	C	83.0	0.0135	0.0802	16.82%	79.5%	14.0	68.9	
FW760-1	SFR	C	83.0	0.0164	0.0802	20.48%	100.0%	17.0	85.9	
FW760-1	Hay/Pasture	D	80.0	0.0000	0.0802	0.02%	100.0%	0.0	85.9	**85.9**
FW770-1	Developed, Low Intensity	C	80.0	0.0000	0.1655	0.01%	0.0%	0.0	0.0	
FW770-1	Developed, Low Intensity	C	80.0	0.0000	0.1655	0.01%	0.0%	0.0	0.0	
FW770-1	Developed, Low Intensity	C	80.0	0.0001	0.1655	0.04%	0.1%	0.0	0.0	
FW770-1	Developed, Low Intensity	C	80.0	0.0003	0.1655	0.16%	0.2%	0.1	0.2	
FW770-1	Developed, Low Intensity	C	80.0	0.0003	0.1655	0.18%	0.4%	0.1	0.3	
FW770-1	Developed, Low Intensity	C	80.0	0.0005	0.1655	0.28%	0.7%	0.2	0.5	
FW770-1	Developed, Low Intensity	C	80.0	0.0008	0.1655	0.46%	1.1%	0.4	0.9	
FW770-1	Developed, Low Intensity	C	80.0	0.0017	0.1655	1.02%	2.2%	0.8	1.7	
FW770-1	Developed, Low Intensity	C	80.0	0.0027	0.1655	1.64%	3.8%	1.3	3.0	
FW770-1	Developed, Open Space	C	74.0	0.0000	0.1655	0.01%	3.8%	0.0	3.1	
FW770-1	Developed, Open Space	C	74.0	0.0001	0.1655	0.06%	3.9%	0.0	3.1	
FW770-1	Developed, Open Space	C	74.0	0.0001	0.1655	0.08%	4.0%	0.1	3.2	
FW770-1	Developed, Open Space	C	74.0	0.0002	0.1655	0.14%	4.1%	0.1	3.3	
FW770-1	Developed, Open Space	C	74.0	0.0003	0.1655	0.20%	4.3%	0.1	3.4	
FW770-1	Developed, Open Space	C	74.0	0.0191	0.1655	11.51%	15.8%	8.5	11.9	
FW770-1	Hay/Pasture	C	74.0	0.0000	0.1655	0.01%	15.8%	0.0	11.9	
FW770-1	POS	C	74.0	0.0001	0.1655	0.06%	15.9%	0.0	12.0	
FW770-1	POS	C	74.0	0.0002	0.1655	0.10%	16.0%	0.1	12.0	
FW770-1	POS	C	74.0	0.0002	0.1655	0.11%	16.1%	0.1	12.1	
FW770-1	POS	C	74.0	0.0003	0.1655	0.15%	16.2%	0.1	12.2	
FW770-1	POS	C	74.0	0.0004	0.1655	0.26%	16.5%	0.2	12.4	
FW770-1	POS	C	74.0	0.0004	0.1655	0.27%	16.8%	0.2	12.6	
FW770-1	POS	C	74.0	0.0015	0.1655	0.92%	17.7%	0.7	13.3	
FW770-1	POS	C	74.0	0.0021	0.1655	1.26%	18.9%	0.9	14.2	
FW770-1	POS	C	74.0	0.0024	0.1655	1.46%	20.4%	1.1	15.3	
FW770-1	POS	C	74.0	0.0027	0.1655	1.62%	22.0%	1.2	16.5	
FW770-1	POS	C	74.0	0.0046	0.1655	2.75%	24.8%	2.0	18.5	
FW770-1	POS	C	74.0	0.0057	0.1655	3.47%	28.2%	2.6	21.1	
FW770-1	ROW	C	98.0	0.0000	0.1655	0.00%	28.2%	0.0	21.1	
FW770-1	ROW	C	98.0	0.0006	0.1655	0.38%	28.6%	0.4	21.5	
FW770-1	ROW	C	98.0	0.0307	0.1655	18.53%	47.1%	18.2	39.7	
FW770-1	SFR	C	83.0	0.0003	0.1655	0.18%	47.3%	0.1	39.8	
FW770-1	SFR	C	83.0	0.0005	0.1655	0.32%	47.6%	0.3	40.1	
FW770-1	SFR	C	83.0	0.0009	0.1655	0.52%	48.2%	0.4	40.5	
FW770-1	SFR	C	83.0	0.0009	0.1655	0.54%	48.7%	0.4	41.0	
FW770-1	SFR	C	83.0	0.0012	0.1655	0.72%	49.4%	0.6	41.5	
FW770-1	SFR	C	83.0	0.0015	0.1655	0.93%	50.4%	0.8	42.3	
FW770-1	SFR	C	83.0	0.0016	0.1655	0.94%	51.3%	0.8	43.1	
FW770-1	SFR	C	83.0	0.0016	0.1655	0.94%	52.2%	0.8	43.9	
FW770-1	SFR	C	83.0	0.0016	0.1655	0.98%	53.2%	0.8	44.7	
FW770-1	SFR	C	83.0	0.0016	0.1655	0.99%	54.2%	0.8	45.5	
FW770-1	SFR	C	83.0	0.0017	0.1655	1.03%	55.2%	0.9	46.4	
FW770-1	SFR	C	83.0	0.0022	0.1655	1.33%	56.6%	1.1	47.5	

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
FW770-1	SFR	C	83.0	0.0023	0.1655	1.38%	57.9%	1.1	48.6	
FW770-1	SFR	C	83.0	0.0024	0.1655	1.45%	59.4%	1.2	49.8	
FW770-1	SFR	C	83.0	0.0027	0.1655	1.64%	61.0%	1.4	51.2	
FW770-1	SFR	C	83.0	0.0029	0.1655	1.73%	62.8%	1.4	52.6	
FW770-1	SFR	C	83.0	0.0030	0.1655	1.81%	64.6%	1.5	54.1	
FW770-1	SFR	C	83.0	0.0031	0.1655	1.86%	66.4%	1.5	55.7	
FW770-1	SFR	C	83.0	0.0032	0.1655	1.94%	68.4%	1.6	57.3	
FW770-1	SFR	C	83.0	0.0033	0.1655	2.02%	70.4%	1.7	59.0	
FW770-1	SFR	C	83.0	0.0038	0.1655	2.28%	72.7%	1.9	60.9	
FW770-1	SFR	C	83.0	0.0039	0.1655	2.36%	75.1%	2.0	62.8	
FW770-1	SFR	C	83.0	0.0040	0.1655	2.43%	77.5%	2.0	64.8	
FW770-1	SFR	C	83.0	0.0043	0.1655	2.59%	80.1%	2.1	67.0	
FW770-1	SFR	C	83.0	0.0046	0.1655	2.80%	82.9%	2.3	69.3	
FW770-1	SFR	C	83.0	0.0051	0.1655	3.06%	85.9%	2.5	71.8	
FW770-1	SFR	C	83.0	0.0075	0.1655	4.54%	90.5%	3.8	75.6	
FW770-1	SFR	C	83.0	0.0091	0.1655	5.49%	96.0%	4.6	80.2	
FW770-1	UDV	C	83.0	0.0056	0.1655	3.37%	99.3%	2.8	83.0	
FW770-1	VACANT	C	91.0	0.0000	0.1655	0.02%	99.4%	0.0	83.0	
FW770-1	VACANT	C	91.0	0.0001	0.1655	0.04%	99.4%	0.0	83.0	
FW770-1	VACANT	C	91.0	0.0004	0.1655	0.26%	99.7%	0.2	83.3	
FW770-1	VACANT	C	91.0	0.0005	0.1655	0.33%	100.0%	0.3	83.6	**83.6**
FW820-1	POS	C	74.0	0.0000	0.0072	0.00%	0.0%	0.0	0.0	
FW820-1	POS	C	74.0	0.0066	0.0072	91.36%	91.4%	67.6	67.6	
FW820-1	ROW	C	98.0	0.0003	0.0072	4.20%	95.6%	4.1	71.7	
FW820-1	SFR	C	83.0	0.0000	0.0072	0.14%	95.7%	0.1	71.8	
FW820-1	SFR	C	83.0	0.0003	0.0072	4.12%	99.8%	3.4	75.3	
FW820-1	VACANT	C	91.0	0.0000	0.0072	0.18%	100.0%	0.2	75.4	**75.4**
FW860-1	AP	C	90.0	0.0214	0.0698	30.60%	30.6%	27.5	27.5	
FW860-1	Cultivated Crops	C	81.0	0.0015	0.0698	2.12%	32.7%	1.7	29.3	
FW860-1	Developed, Low Intensity	C	80.0	0.0000	0.0698	0.00%	32.7%	0.0	29.3	
FW860-1	Hay/Pasture	C	74.0	0.0007	0.0698	1.05%	33.8%	0.8	30.0	
FW860-1	Hay/Pasture	C	74.0	0.0320	0.0698	45.84%	79.6%	33.9	64.0	
FW860-1	MFR	C	90.0	0.0003	0.0698	0.36%	80.0%	0.3	64.3	
FW860-1	ROW	C	98.0	0.0016	0.0698	2.26%	82.2%	2.2	66.5	
FW860-1	SEF	C	86.0	0.0095	0.0698	13.63%	95.9%	11.7	78.2	
FW860-1	AP	D	92.0	0.0008	0.0698	1.21%	97.1%	1.1	79.3	
FW860-1	Developed, Low Intensity	D	85.0	0.0001	0.0698	0.08%	97.2%	0.1	79.4	
FW860-1	Developed, Open Space	D	80.0	0.0002	0.0698	0.32%	97.5%	0.3	79.7	
FW860-1	Hay/Pasture	D	80.0	0.0002	0.0698	0.22%	97.7%	0.2	79.8	
FW860-1	MFR	D	92.0	0.0007	0.0698	0.94%	98.6%	0.9	80.7	
FW860-1	POS	D	80.0	0.0010	0.0698	1.36%	100.0%	1.1	81.8	**81.8**
FW960-1	Hay/Pasture	C	74.0	0.0000	0.0282	0.01%	0.0%	0.0	0.0	
FW960-1	Hay/Pasture	C	74.0	0.0097	0.0282	34.53%	34.5%	25.6	25.6	
FW960-1	POS	C	74.0	0.0001	0.0282	0.34%	34.9%	0.3	25.8	
FW960-1	POS	C	74.0	0.0003	0.0282	0.90%	35.8%	0.7	26.5	
FW960-1	POS	C	74.0	0.0041	0.0282	14.70%	50.5%	10.9	37.4	
FW960-1	ROW	C	98.0	0.0067	0.0282	23.70%	74.2%	23.2	60.6	
FW960-1	SFR	C	83.0	0.0007	0.0282	2.50%	76.7%	2.1	62.7	
FW960-1	SFR	C	83.0	0.0008	0.0282	2.74%	79.4%	2.3	64.9	
FW960-1	SFR	C	83.0	0.0010	0.0282	3.67%	83.1%	3.0	68.0	
FW960-1	SFR	C	83.0	0.0011	0.0282	3.72%	86.8%	3.1	71.1	
FW960-1	SFR	C	83.0	0.0011	0.0282	3.77%	90.6%	3.1	74.2	
FW960-1	SFR	C	83.0	0.0011	0.0282	3.95%	94.5%	3.3	77.5	
FW960-1	SFR	C	83.0	0.0015	0.0282	5.45%	100.0%	4.5	82.0	**82.0**
W1340	Cultivated Crops	B	72.0	0.0339	0.1631	20.75%	20.8%	14.9	14.9	
W1340	Developed, Open Space	B	61.0	0.0058	0.1631	3.54%	24.3%	2.2	17.1	
W1340	Hay/Pasture	B	61.0	0.0730	0.1631	44.78%	69.1%	27.3	44.4	

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W1340	Cultivated Crops	C	81.0	0.0287	0.1631	17.57%	86.6%	14.2	58.6	
W1340	Developed, Open Space	C	74.0	0.0040	0.1631	2.43%	89.1%	1.8	60.4	
W1340	Hay/Pasture	C	74.0	0.0178	0.1631	10.94%	100.0%	8.1	68.5	**68.5**
W180	CR	B	92.0	0.0017	0.1603	1.05%	1.0%	1.0	1.0	
W180	DTR	B	85.0	0.0001	0.1603	0.03%	1.1%	0.0	1.0	
W180	MFR	B	85.0	0.0041	0.1603	2.56%	3.6%	2.2	3.2	
W180	ROW	B	98.0	0.0036	0.1603	2.23%	5.9%	2.2	5.3	
W180	SFR	B	75.0	0.0005	0.1603	0.31%	6.2%	0.2	5.6	
W180	VACANT	B	86.0	0.0000	0.1603	0.00%	6.2%	0.0	5.6	
W180	CHURCH	C	94.0	0.0000	0.1603	0.00%	6.2%	0.0	5.6	
W180	CR	C	94.0	0.0009	0.1603	0.56%	6.7%	0.5	6.1	
W180	Developed, Low Intensity	C	80.0	0.0019	0.1603	1.20%	7.9%	1.0	7.1	
W180	Developed, Open Space	C	74.0	0.0142	0.1603	8.89%	16.8%	6.6	13.6	
W180	DTR	C	90.0	0.0006	0.1603	0.35%	17.2%	0.3	14.0	
W180	MFR	C	90.0	0.0172	0.1603	10.74%	27.9%	9.7	23.6	
W180	POS	C	74.0	0.0281	0.1603	17.55%	45.5%	13.0	36.6	
W180	ROW	C	98.0	0.0169	0.1603	10.57%	56.0%	10.4	47.0	
W180	SEF	C	86.0	0.0030	0.1603	1.89%	57.9%	1.6	48.6	
W180	SFR	C	83.0	0.0641	0.1603	40.02%	97.9%	33.2	81.8	
W180	VACANT	C	91.0	0.0033	0.1603	2.07%	100.0%	1.9	83.7	**83.7**
W210	Developed, Low Intensity	C	80.0	0.0040	0.0879	4.58%	4.6%	3.7	3.7	
W210	Developed, Open Space	C	74.0	0.0266	0.0879	30.28%	34.9%	22.4	26.1	
W210	Hay/Pasture	C	74.0	0.0054	0.0879	6.12%	41.0%	4.5	30.6	
W210	MFR	C	90.0	0.0002	0.0879	0.23%	41.2%	0.2	30.8	
W210	POS	C	74.0	0.0142	0.0879	16.17%	57.4%	12.0	42.8	
W210	ROW	C	98.0	0.0028	0.0879	3.20%	60.6%	3.1	45.9	
W210	SFR	C	83.0	0.0131	0.0879	14.90%	75.5%	12.4	58.3	
W210	VACANT	C	91.0	0.0041	0.0879	4.69%	80.2%	4.3	62.5	
W210	Developed, Open Space	D	80.0	0.0096	0.0879	10.88%	91.1%	8.7	71.2	
W210	Hay/Pasture	D	80.0	0.0016	0.0879	1.79%	92.8%	1.4	72.7	
W210	MFR	D	92.0	0.0000	0.0879	0.01%	92.8%	0.0	72.7	
W210	POS	D	80.0	0.0012	0.0879	1.41%	94.3%	1.1	73.8	
W210	SFR	D	87.0	0.0048	0.0879	5.43%	99.7%	4.7	78.5	
W210	Woody Wetlands	D	78.0	0.0003	0.0879	0.31%	100.0%	0.2	78.8	**78.8**
W211	Developed, Open Space	B	61.0	0.0001	0.1657	0.04%	0.0%	0.0	0.0	
W211	POS	B	61.0	0.0019	0.1657	1.14%	1.2%	0.7	0.7	
W211	ROW	B	98.0	0.0027	0.1657	1.60%	2.8%	1.6	2.3	
W211	SFR	B	75.0	0.0025	0.1657	1.53%	4.3%	1.1	3.4	
W211	VACANT	B	86.0	0.0029	0.1657	1.78%	6.1%	1.5	5.0	
W211	Cultivated Crops	C	81.0	0.0113	0.1657	6.81%	12.9%	5.5	10.5	
W211	Developed, Low Intensity	C	80.0	0.0040	0.1657	2.40%	15.3%	1.9	12.4	
W211	Developed, Open Space	C	74.0	0.0024	0.1657	1.46%	16.8%	1.1	13.5	
W211	Developed, Open Space	C	74.0	0.0294	0.1657	17.72%	34.5%	13.1	26.6	
W211	Evergreen Forest	C	70.0	0.0010	0.1657	0.58%	35.1%	0.4	27.0	
W211	Evergreen Forest	C	70.0	0.0017	0.1657	1.01%	36.1%	0.7	27.7	
W211	Hay/Pasture	C	74.0	0.0002	0.1657	0.14%	36.2%	0.1	27.8	
W211	Hay/Pasture	C	74.0	0.0240	0.1657	14.48%	50.7%	10.7	38.5	
W211	POS	C	74.0	0.0214	0.1657	12.91%	63.6%	9.6	48.1	
W211	ROW	C	98.0	0.0069	0.1657	4.15%	67.8%	4.1	52.2	
W211	SFR	C	83.0	0.0153	0.1657	9.24%	77.0%	7.7	59.8	
W211	Shrub/Scrub	C	65.0	0.0000	0.1657	0.01%	77.0%	0.0	59.8	
W211	UDV	C	83.0	0.0031	0.1657	1.88%	78.9%	1.6	61.4	
W211	VACANT	C	91.0	0.0032	0.1657	1.93%	80.8%	1.8	63.1	
W211	Developed, Low Intensity	D	85.0	0.0006	0.1657	0.33%	81.2%	0.3	63.4	
W211	Developed, Open Space	D	80.0	0.0072	0.1657	4.35%	85.5%	3.5	66.9	
W211	Hay/Pasture	D	80.0	0.0062	0.1657	3.76%	89.3%	3.0	69.9	
W211	POS	D	80.0	0.0123	0.1657	7.39%	96.7%	5.9	75.8	

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W211	ROW	D	98.0	0.0010	0.1657	0.59%	97.2%	0.6	76.4	
W211	UDV	D	87.0	0.0012	0.1657	0.70%	98.0%	0.6	77.0	
W211	VACANT	D	94.0	0.0034	0.1657	2.05%	100.0%	1.9	79.0	**79.0**
W220	POS	B	61.0	0.0010	0.0553	1.73%	1.7%	1.1	1.1	
W220	ROW	B	98.0	0.0057	0.0553	10.26%	12.0%	10.1	11.1	
W220	SFR	B	75.0	0.0053	0.0553	9.55%	21.5%	7.2	18.3	
W220	VACANT	B	86.0	0.0036	0.0553	6.42%	28.0%	5.5	23.8	
W220	MFR	C	90.0	0.0007	0.0553	1.22%	29.2%	1.1	24.9	
W220	POS	C	74.0	0.0032	0.0553	5.80%	35.0%	4.3	29.2	
W220	ROW	C	98.0	0.0128	0.0553	23.20%	58.2%	22.7	51.9	
W220	SFR	C	83.0	0.0157	0.0553	28.32%	86.5%	23.5	75.4	
W220	VACANT	C	91.0	0.0075	0.0553	13.49%	100.0%	12.3	87.7	
W220	POS	D	80.0	0.0000	0.0553	0.01%	100.0%	0.0	87.7	**87.7**
W221	POS	B	61.0	0.0023	0.0723	3.25%	3.2%	2.0	2.0	
W221	ROW	B	98.0	0.0024	0.0723	3.36%	6.6%	3.3	5.3	
W221	SFR	B	75.0	0.0042	0.0723	5.83%	12.4%	4.4	9.6	
W221	VACANT	B	86.0	0.0005	0.0723	0.68%	13.1%	0.6	10.2	
W221	Cultivated Crops	C	81.0	0.0064	0.0723	8.89%	22.0%	7.2	17.4	
W221	Developed, Low Intensity	C	80.0	0.0001	0.0723	0.12%	22.1%	0.1	17.5	
W221	Developed, Open Space	C	74.0	0.0044	0.0723	6.06%	28.2%	4.5	22.0	
W221	Hay/Pasture	C	74.0	0.0029	0.0723	4.00%	32.2%	3.0	25.0	
W221	POS	C	74.0	0.0164	0.0723	22.72%	54.9%	16.8	41.8	
W221	ROW	C	98.0	0.0083	0.0723	11.46%	66.4%	11.2	53.0	
W221	SFR	C	83.0	0.0191	0.0723	26.44%	92.8%	21.9	75.0	
W221	Shrub/Scrub	C	65.0	0.0036	0.0723	4.98%	97.8%	3.2	78.2	
W221	VACANT	C	91.0	0.0016	0.0723	2.21%	100.0%	2.0	80.2	**80.2**
W250	Cultivated Crops	B	72.0	0.0294	0.1381	21.29%	21.3%	15.3	15.3	
W250	Developed, Low Intensity	B	70.0	0.0000	0.1381	0.00%	21.3%	0.0	15.3	
W250	Developed, Open Space	B	61.0	0.0045	0.1381	3.28%	24.6%	2.0	17.3	
W250	Hay/Pasture	B	61.0	0.0384	0.1381	27.82%	52.4%	17.0	34.3	
W250	ROW	B	98.0	0.0000	0.1381	0.00%	52.4%	0.0	34.3	
W250	Shrub/Scrub	B	48.0	0.0018	0.1381	1.30%	53.7%	0.6	34.9	
W250	Cultivated Crops	C	81.0	0.0155	0.1381	11.25%	65.0%	9.1	44.0	
W250	Developed, Low Intensity	C	80.0	0.0008	0.1381	0.61%	65.6%	0.5	44.5	
W250	Developed, Open Space	C	74.0	0.0090	0.1381	6.51%	72.1%	4.8	49.3	
W250	Hay/Pasture	C	74.0	0.0360	0.1381	26.03%	98.1%	19.3	68.6	
W250	ROW	C	98.0	0.0005	0.1381	0.34%	98.4%	0.3	68.9	
W250	Shrub/Scrub	C	65.0	0.0009	0.1381	0.67%	99.1%	0.4	69.4	
W250	Developed, Open Space	D	80.0	0.0009	0.1381	0.68%	99.8%	0.5	69.9	
W250	Hay/Pasture	D	80.0	0.0003	0.1381	0.21%	100.0%	0.2	70.1	**70.1**
W251	Cultivated Crops	B	72.0	0.0210	0.0866	24.25%	24.2%	17.5	17.5	
W251	Developed, Low Intensity	B	70.0	0.0004	0.0866	0.43%	24.7%	0.3	17.8	
W251	Developed, Open Space	B	61.0	0.0037	0.0866	4.30%	29.0%	2.6	20.4	
W251	Hay/Pasture	B	61.0	0.0341	0.0866	39.34%	68.3%	24.0	44.4	
W251	Cultivated Crops	C	81.0	0.0121	0.0866	13.95%	82.3%	11.3	55.7	
W251	Developed, Low Intensity	C	80.0	0.0019	0.0866	2.16%	84.4%	1.7	57.4	
W251	Developed, Open Space	C	74.0	0.0038	0.0866	4.43%	88.9%	3.3	60.7	
W251	Hay/Pasture	C	74.0	0.0096	0.0866	11.14%	100.0%	8.2	68.9	**68.9**
W260	Hay/Pasture	B	61.0	0.0000	0.2779	0.01%	0.0%	0.0	0.0	
W260	Cultivated Crops	C	81.0	0.1753	0.2779	63.07%	63.1%	51.1	51.1	
W260	Developed, Open Space	C	74.0	0.0088	0.2779	3.17%	66.2%	2.3	53.4	
W260	Evergreen Forest	C	70.0	0.0014	0.2779	0.50%	66.7%	0.4	53.8	
W260	Hay/Pasture	C	74.0	0.0862	0.2779	31.02%	97.8%	23.0	76.7	
W260	Shrub/Scrub	C	65.0	0.0062	0.2779	2.24%	100.0%	1.5	78.2	**78.2**
W270	Cultivated Crops	B	72.0	0.0261	0.1926	13.54%	13.5%	9.7	9.7	
W270	Developed, Low Intensity	B	70.0	0.0013	0.1926	0.69%	14.2%	0.5	10.2	
W270	Developed, Open Space	B	61.0	0.0167	0.1926	8.65%	22.9%	5.3	15.5	

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
W270	Hay/Pasture	B	61.0	0.0292	0.1926	15.17%	38.0%	9.3	24.8	
W270	Herbaceuous	B	62.0	0.0004	0.1926	0.21%	38.3%	0.1	24.9	
W270	Shrub/Scrub	B	48.0	0.0014	0.1926	0.72%	39.0%	0.3	25.2	
W270	Cultivated Crops	C	81.0	0.0211	0.1926	10.96%	49.9%	8.9	34.1	
W270	Developed, Low Intensity	C	80.0	0.0028	0.1926	1.45%	51.4%	1.2	35.3	
W270	Developed, Open Space	C	74.0	0.0179	0.1926	9.30%	60.7%	6.9	42.2	
W270	Hay/Pasture	C	74.0	0.0614	0.1926	31.89%	92.6%	23.6	65.8	
W270	Herbaceuous	C	74.0	0.0105	0.1926	5.48%	98.1%	4.1	69.8	
W270	Shrub/Scrub	C	65.0	0.0037	0.1926	1.94%	100.0%	1.3	71.1	**71.1**
W280	Cultivated Crops	C	81.0	0.0119	0.0845	14.08%	14.1%	11.4	11.4	
W280	Developed, Low Intensity	C	80.0	0.0051	0.0845	6.08%	20.2%	4.9	16.3	
W280	Developed, Open Space	C	74.0	0.0315	0.0845	37.27%	57.4%	27.6	43.8	
W280	Hay/Pasture	C	74.0	0.0127	0.0845	15.01%	72.4%	11.1	55.0	
W280	Herbaceuous	C	74.0	0.0197	0.0845	23.32%	95.8%	17.3	72.2	
W280	Shrub/Scrub	C	65.0	0.0036	0.0845	4.25%	100.0%	2.8	75.0	**75.0**
W290	Developed, Low Intensity	C	80.0	0.0199	0.1105	18.02%	18.0%	14.4	14.4	
W290	Developed, Open Space	C	74.0	0.0906	0.1105	81.98%	100.0%	60.7	75.1	**75.1**
W300	Deciduous Forest	B	55.0	0.0183	1.1410	1.60%	1.6%	0.9	0.9	
W300	Developed, Open Space	B	61.0	0.0010	1.1410	0.09%	1.7%	0.1	0.9	
W300	Evergreen Forest	B	55.0	0.0273	1.1410	2.39%	4.1%	1.3	2.2	
W300	Evergreen Forest	B	55.0	0.2438	1.1410	21.37%	25.4%	11.8	14.0	
W300	Herbaceuous	B	62.0	0.0004	1.1410	0.04%	25.5%	0.0	14.0	
W300	Mixed Forest	B	55.0	0.0001	1.1410	0.01%	25.5%	0.0	14.0	
W300	Shrub/Scrub	B	48.0	0.0023	1.1410	0.20%	25.7%	0.1	14.1	
W300	Cultivated Crops	C	81.0	0.1167	1.1410	10.23%	35.9%	8.3	22.4	
W300	Deciduous Forest	C	70.0	0.0038	1.1410	0.34%	36.3%	0.2	22.6	
W300	Developed, Low Intensity	C	80.0	0.0413	1.1410	3.62%	39.9%	2.9	25.5	
W300	Developed, Open Space	C	74.0	0.3923	1.1410	34.38%	74.3%	25.4	51.0	
W300	Evergreen Forest	C	70.0	0.0019	1.1410	0.16%	74.4%	0.1	51.1	
W300	Hay/Pasture	C	74.0	0.1606	1.1410	14.08%	88.5%	10.4	61.5	
W300	Herbaceuous	C	74.0	0.0087	1.1410	0.76%	89.3%	0.6	62.1	
W300	Mixed Forest	C	70.0	0.0008	1.1410	0.07%	89.3%	0.1	62.1	
W300	Shrub/Scrub	C	65.0	0.1216	1.1410	10.66%	100.0%	6.9	69.1	**69.1**
W320	Developed, Low Intensity	B	70.0	0.0004	0.1510	0.23%	0.2%	0.2	0.2	
W320	Developed, Open Space	B	61.0	0.0006	0.1510	0.39%	0.6%	0.2	0.4	
W320	DTR	B	85.0	0.0097	0.1510	6.41%	7.0%	5.5	5.8	
W320	MFR	B	85.0	0.0058	0.1510	3.85%	10.9%	3.3	9.1	
W320	POS	B	61.0	0.0116	0.1510	7.68%	18.6%	4.7	13.8	
W320	ROW	B	98.0	0.0241	0.1510	15.99%	34.6%	15.7	29.5	
W320	SFR	B	75.0	0.0388	0.1510	25.71%	60.3%	19.3	48.8	
W320	Shrub/Scrub	B	48.0	0.0002	0.1510	0.13%	60.4%	0.1	48.8	
W320	CR	C	94.0	0.0009	0.1510	0.61%	61.0%	0.6	49.4	
W320	Developed, Low Intensity	C	80.0	0.0001	0.1510	0.07%	61.1%	0.1	49.5	
W320	Developed, Open Space	C	74.0	0.0000	0.1510	0.00%	61.1%	0.0	49.5	
W320	DTR	C	90.0	0.0012	0.1510	0.83%	61.9%	0.7	50.2	
W320	DTR	C	90.0	0.0048	0.1510	3.19%	65.1%	2.9	53.1	
W320	GOLF	C	94.0	0.0001	0.1510	0.04%	65.1%	0.0	53.1	
W320	LM	C	94.0	0.0109	0.1510	7.24%	72.4%	6.8	59.9	
W320	MFR	C	90.0	0.0017	0.1510	1.16%	73.5%	1.0	61.0	
W320	MFR	C	90.0	0.0116	0.1510	7.70%	81.2%	6.9	67.9	
W320	MIXED	C	84.0	0.0001	0.1510	0.06%	81.3%	0.0	67.9	
W320	POS	C	74.0	0.0000	0.1510	0.00%	81.3%	0.0	67.9	
W320	POS	C	74.0	0.0049	0.1510	3.26%	84.6%	2.4	70.4	
W320	ROW	C	98.0	0.0047	0.1510	3.10%	87.7%	3.0	73.4	
W320	ROW	C	98.0	0.0078	0.1510	5.17%	92.8%	5.1	78.5	
W320	SFR	C	83.0	0.0006	0.1510	0.39%	93.2%	0.3	78.8	
W320	SFR	C	83.0	0.0057	0.1510	3.79%	97.0%	3.1	81.9	

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
W320	UDV	C	83.0	0.0000	0.1510	0.02%	97.0%	0.0	82.0	
W320	Developed, Low Intensity	D	85.0	0.0001	0.1510	0.07%	97.1%	0.1	82.0	
W320	DTR	D	92.0	0.0009	0.1510	0.58%	97.7%	0.5	82.5	
W320	MFR	D	92.0	0.0009	0.1510	0.58%	98.3%	0.5	83.1	
W320	POS	D	80.0	0.0001	0.1510	0.04%	98.3%	0.0	83.1	
W320	ROW	D	98.0	0.0011	0.1510	0.76%	99.1%	0.7	83.9	
W320	SFR	D	87.0	0.0014	0.1510	0.92%	100.0%	0.8	84.7	
W320	Shrub/Scrub	D	73.0	0.0000	0.1510	0.02%	100.0%	0.0	84.7	**84.7**
W370	DTR	B	85.0	0.0004	0.0493	0.86%	0.9%	0.7	0.7	
W370	MFR	B	85.0	0.0019	0.0493	3.91%	4.8%	3.3	4.1	
W370	POS	B	61.0	0.0080	0.0493	16.20%	21.0%	9.9	13.9	
W370	ROW	B	98.0	0.0022	0.0493	4.41%	25.4%	4.3	18.3	
W370	SFR	B	75.0	0.0032	0.0493	6.47%	31.8%	4.8	23.1	
W370	AP	C	90.0	0.0003	0.0493	0.61%	32.5%	0.5	23.7	
W370	CA	C	94.0	0.0005	0.0493	0.94%	33.4%	0.9	24.5	
W370	CR	C	94.0	0.0005	0.0493	0.92%	34.3%	0.9	25.4	
W370	MFR	C	90.0	0.0001	0.0493	0.28%	34.6%	0.2	25.7	
W370	MIXED	C	84.0	0.0020	0.0493	4.12%	38.7%	3.5	29.1	
W370	POS	C	74.0	0.0047	0.0493	9.53%	48.2%	7.1	36.2	
W370	RB	C	94.0	0.0000	0.0493	0.05%	48.3%	0.0	36.2	
W370	ROW	C	98.0	0.0054	0.0493	11.06%	59.3%	10.8	47.0	
W370	SFR	C	83.0	0.0036	0.0493	7.36%	66.7%	6.1	53.2	
W370	VACANT	C	91.0	0.0002	0.0493	0.36%	67.1%	0.3	53.5	
W370	AP	D	92.0	0.0019	0.0493	3.90%	71.0%	3.6	57.1	
W370	DTR	D	92.0	0.0000	0.0493	0.00%	71.0%	0.0	57.1	
W370	MFR	D	92.0	0.0000	0.0493	0.05%	71.0%	0.0	57.1	
W370	MIXED	D	88.0	0.0002	0.0493	0.47%	71.5%	0.4	57.5	
W370	POS	D	80.0	0.0082	0.0493	16.62%	88.1%	13.3	70.8	
W370	RB	D	95.0	0.0005	0.0493	1.10%	89.2%	1.0	71.9	
W370	ROW	D	98.0	0.0009	0.0493	1.91%	91.1%	1.9	73.7	
W370	SFR	D	87.0	0.0042	0.0493	8.47%	99.6%	7.4	81.1	
W370	VACANT	D	94.0	0.0002	0.0493	0.41%	100.0%	0.4	81.5	**81.5**
W380	DTR	B	85.0	0.0000	0.0114	0.00%	0.0%	0.0	0.0	
W380	POS	B	61.0	0.0000	0.0114	0.41%	0.4%	0.2	0.2	
W380	ROW	B	98.0	0.0001	0.0114	1.19%	1.6%	1.2	1.4	
W380	SFR	B	75.0	0.0002	0.0114	1.67%	3.3%	1.3	2.7	
W380	DTR	C	90.0	0.0001	0.0114	1.16%	4.4%	1.0	3.7	
W380	MFR	C	90.0	0.0000	0.0114	0.06%	4.5%	0.1	3.8	
W380	POS	C	74.0	0.0016	0.0114	13.90%	18.4%	10.3	14.1	
W380	ROW	C	98.0	0.0020	0.0114	17.94%	36.3%	17.6	31.6	
W380	SFR	C	83.0	0.0073	0.0114	63.67%	100.0%	52.8	84.5	**84.5**

Appendix E. Lag Time Calculations

Calculation of Lag and Tc
Curve Number Method

Basin	CN	Avg Basin Slope (%)	Longest flow path (ft)	Lag (hr)	Lag (min)	Tc (hr)	Tc (min)
		FROM 10m DEM					
FW100-1	77.5	1.47	1605	0.41	24.82	0.69	41.37
FW1370-1	86.9	2.92	3008	0.35	21.30	0.59	35.49
FW1520-1	87.7	2.88	3797	0.42	25.13	0.70	41.88
FW1700-1	97.7	1.72	298	0.04	2.66	0.07	6.00
FW170-1	76.4	1.68	917	0.26	15.32	0.43	25.54
FW1720-1	90.0	2.95	1919	0.22	13.12	0.36	21.86
FW1800-1	84.4	1.93	3417	0.53	31.76	0.88	52.93
FW1850-1	83.3	3.17	2186	0.30	17.98	0.50	29.96
FW1900-1	78.3	1.40	4319	0.91	54.79	1.52	91.32
FW1950-1	78.2	1.46	7516	1.40	83.72	2.33	139.53
FW2160-1	80.8	1.39	2587	0.56	33.81	0.94	56.35
FW220-1	85.5	2.26	1703	0.27	16.16	0.45	26.93
FW260-1	90.5	1.71	726	0.13	7.76	0.22	12.94
FW2800-1	82.4	1.74	7305	1.10	65.81	1.83	109.68
FW330-1	75.5	1.53	3758	0.85	50.75	1.41	84.58
FW430-1	79.9	1.40	1548	0.38	22.89	0.64	38.15
FW470-1	76.9	1.41	3272	0.76	45.60	1.27	76.00
FW630-1	75.7	1.53	3932	0.87	52.45	1.46	87.41
FW710-1	86.2	2.21	3612	0.48	29.10	0.81	48.50
FW760-1	85.9	1.98	4967	0.67	39.99	1.11	66.65
FW770-1	83.6	1.52	6416	1.02	60.93	1.69	101.55
FW820-1	75.4	2.07	1294	0.31	18.70	0.52	31.17
FW860-1	81.8	1.80	4199	0.70	42.29	1.17	70.49
FW960-1	82.0	1.38	2784	0.58	34.58	0.96	57.63
W1340	68.5	1.48	5895	1.50	90.06	2.50	150.10
W180	83.7	3.21	9031	0.91	54.88	1.52	91.47
W210	78.8	3.36	4932	0.65	38.72	1.08	64.54
W211	79.0	2.46	4911	0.75	44.84	1.25	74.73
W220	87.7	1.39	3488	0.56	33.72	0.94	56.21
W221	80.2	1.99	4784	0.78	46.94	1.30	78.24
W250	70.1	1.45	6524	1.58	94.50	2.63	157.50
W251	68.9	1.30	3946	1.15	68.77	1.91	114.61
W260	78.2	1.66	7631	1.33	79.58	2.21	132.63
W270	71.1	1.62	5870	1.33	79.91	2.22	133.18
W280	75.0	1.87	5072	0.99	59.46	1.65	99.10
W290	75.1	1.95	4293	0.85	50.71	1.41	84.51
W300	69.1	9.87	17839	1.39	83.27	2.31	138.78
W320	84.7	1.39	6705	1.06	63.47	1.76	105.79
W370	81.5	1.56	3569	0.67	40.27	1.12	67.12
W380	84.5	1.71	1383	0.27	16.31	0.45	27.19

*According to the SCS Handbook, the engineer should use a Tc equal to 0.1 hr (6 min) if the computed Tc is less than 0.1 hr.