QUARTERLY REPORT

(October 2011-September 2012)

Activities conducted by the U.S. Geological Survey for the project:

FLOOD-FREQUENCY ANALYSES FOR U.S. GEOLOGICAL GAGING STATIONS BASED ON DATA THROUGH WATER YEAR 2011

I. Introduction

This report summarizes planned activities and work conducted by the U.S. Geological Survey (USGS) during the reporting quarters for the project: Flood-Frequency Analyses for U.S. Geological Survey Gaging Stations Based on Data through Water Year 2011. This project is cooperatively funded through Montana Department of Transportation (MDT), Montana Department of Natural Resources and Conservation (DNRC), and the USGS Cooperative Water Program (http://water.usgs.gov/coop/).

While initially proposed to include data through water year 2009, flooding in 2011 was substantial at a large number of USGS gaging stations. An initial analysis of the records including WY2010 and WY2011 data significantly altered the resulting flood frequency datasets in comparisons to analyses completed with data through WY2009. Additionally, the Montana Water Science Center will be preparing flood frequency analyses for active gages in the greater Missouri River Basin using data through 2011 for publication in a national flood report. The scope of work for the flood frequency analysis was therefore amended to include data through WY 2011.

Peak flood values are computed, checked, and reviewed by field personal prior to there entry into the USGS peak flow file. These data were completely entered into the peak flow file in May 2012 for use in computing the flood frequency analsysis at sites in Montana. Basic flood frequency analysis were compiled and completed for all sites in Montana using data through WY 2011. Record extension techniques are being used to develop alternate flood frequency curves for those gages having less than 10 years of flood data.

Table 1, presented at the bottom of this progress report, shows the project schedule by task.

II. Project activities conducted during the reporting quarter presented by task

1a. Document regulatory structures that influence peak flows at gaging stations.

The USGS received a GIS coverage of dams from the Montana Department of Environmental Quality in November 2010. This GIS coverage is an extensive list of reservoirs and diversion dams in Montana and includes 3,667 dams. Each of these dams have several attributes including the name, owner, year built, storage capacity and drainage area which are essential attributes for completion of this task. The USGS has not previously used such an extensive list of reservoirs to determine which stream gages have upstream storage and thus may be affected by dams. A systematic approach was developed to evaluate the effect of these dams on each gaging station. This systematic approach requires a large amount of GIS work which began in late December and has been completed for approximately 94 of 813 gages as of January 10, 2011.

The GIS specialist for Montana Water Science Center is currently working on this task; however additional issues have been identified which will delay this task. A majority of the dams in the provided database do not have accurate latitude and longitude positions. Without accurate latitude and longitude positions the GIS work cannot be easily automated. The Montana Water Science Center is working with other Federal and state agencies to attain a dams database with accurate latitude and longitudinal positions.

Update (9/2011): A separate GIS coverage of dams used in the high-definition NHD+ has been identified as a better source for documenting regulatory structures in Montana. The latitude and longitude of the dams in this database are properly snapped to flowlines in the NHD+ data set and

will thus require much less quality assurance work. However, the new dataset lacks many of the small dams on small streams that the previous data source provided. The current plan is to continue with the NHD+ version of the data.

Update (8/2012): The GIS coverage of dams used in the high-definition NHD+ were originally snapped to high definition flowlines. For the purpose of an ongoing project to develop StreamStats the dams needed to be converted and snapped to the medium resolution flowlines. Some of these dams were snapped automatically to the medium resolution flowlines using GIS routines however a majority of these dams needed to manually be snapped to the correct location. During this procedure it was determined that many of the dams were incorrectly snapped in the high resolution data. USGS personnel reviewed and properly located the dams on medium resolution flowlines.

1b. Construct table of regulating structures and stations influenced.

The systematic approach being used in task 1a will result in a table of regulatory structures for each gage. Although Task 1b has been completed for 94 gages as of January 10, 2011, these gages will need to be re-evaluated when a new dams database is acquired.

No update (9/2011).

Update (8/2011): A table of regulating structures and the station influenced is being developed however to determine whether a gage is downstream from a regulatory structure the gages first need to be snapped to the medium resolution flowlines. A majority of the active gaging stations had been properly located and snapped to flowlines in 2004 however the discontinued gages (>600) had not been snapped. USGS personnel located and snapped these gages in June 2012. Additional GIS work is being completed to finalize NHD+. When this work is completed each gage can be evaluated for regulatory structures upstream.

1c. Retrieve and format peak flow data.

Peak flow data have been retrieved and formatted for all of the stream gages beginning with 06 (part 6 gages) having 10 or more years of record. This accounts for approximately 570 gages. Until task 1a can be completed, regulation is determined from WRIR 03-4308 (Parrett and Johnson, 2003). For a majority of these gages the regulation status will not likely change.

Update (9/2011). Peak flow data have been retrieved and formated for all gages in Montana.

Update (8/2011). Peak flow data using data through 2011 have been retrieved and formatted for all gages in Montana.

1d. Perform flood frequency analyses.

Flood frequency analyses using the standard Bulletin 17B (B17B) approach has been completed for all of the part 6 gages having 10 or more years of record (~570 gages). For those gages which include a historical analysis, the number of years assigned to the historic analysis is being reviewed. Determining the number of years and peak value for a historic analysis requires subjective decisions based on knowledge of the system, drainage area, and hi-story of localized and or regional floods. The Montana Water Science Center has recently received direction from the USGS Office of Surface Water to use PeakfqSA for gages which use a historic analysis. PeakfqSA employs a more general parameter-estimation method, specifically the Expected Moments Algorithm (EMA), to permit efficient use of interval data while performing historic analyses. In addition to incorporating interval data, PeakfqSA also uses EMA to assign more accurate confidence intervals. While PeakfqSA is not the approved B17B method for performing historic analysis, it is being recommended by the Hydrologic Frequency Analysis Work Group for adoption into B17B revisions. Thus, the Montana Water Science Center will present historic analysis using both B17B and EMA methods.

Update (9/2011). Flood frequency analyses using the standard B17B has been completed for all of the gages in Montana. Those gages which have been identified as having a possible mixed-population will need further analyses (see section 4a for further information). Many of the gages having a short period of record will have additional analyses as well to provide an alternative analysis using record extension techniques. Our office has tested PeakfaSA on several gages and at this point it is not reproducing the standard B17B analyses as is should for non-historical analyses. If this issue is not resolved in the near future, the PeakfaSA will not be used to provide an EMA analysis.

Update (8/2011). Flood frequency analyses using the standard B17B have been completed for all of the gages in Montana using data through WY 2011. Those gages which have been identified as having a possible mixed-population will need further analyses (see section 4a for further information). Many of the gages having a short period of record will have additional analyses as well to provide an alternative analysis using record extension techniques.

1e. Construct figures and tables of frequency results and accompanying information

An internal document has been created to track the results and accompanying information for each gage when the flood frequency analyses are performed. This document will be used to develop presentation quality figures and tables upon completion of the analyses task (1d). Interim documents and analyses are being loaded to an ftp site for use by MDT and DNRC. These interim analyses are provisional and are subject to revisions.

Update (9/2011): Approximately 50% of the gages having the basic B17B analysis have been uploaded to the ftp site. Further discussion is needed with the cooperators to determine which gages should be loaded to the ftp sites as much of the data is preliminary and may change with further analyses.

Update (8/2011): All of the data for the Basic B17B data have been tabled and formatted in excel files however these files have not been uploaded to the ftp site.

2a. Identify gaging stations with less than 15 years of record or with longer periods of record but substantially influenced by unusual climatic conditions

This task is performed while performing the basic flood frequency analyses for each gage. Approximately 170 of the part 6 gages have been identified as having between 10 and 15 years of record. Record extension methods will be evaluated for each of these gages. Additional gages identified for record extension included those with records restricted to post-1985 and those which are on the same major stream corridor. For example, there are 14 streamgages along the main-stem of the Milk River. The records for many of these gages may be restricted to shorter periods (10-25) years. Record extension will be used where possible to extend the record for these gages to ensure that flood frequency analyses will align appropriately in downstream order. For those gages where record extension methods are employed, the flood frequency analyses using record extension will be provided in addition to the basic B17B analyses using the systematic and historic records.

Update (9/2011): Gages with less than 15 years of record have been identified for all gages in Montana.

Update (8/2012): Gages with less than 15 years of record have been identified for all gages in Montana.

2b. Conduct correlation analyses to determine appropriate index stations

No correlation analyses have been evaluated.

No update (9/2011).

Update (8/2012): Correlation analyses to determine appropriate index stations is currently (8/2012) underway.

2c. Conduct Bulletin 17b 2-station analyses and MOVE.1 analyses for record extension

No 2-station analyses or MOVE.1 analyses have been performed.

No update (9/2011).

Update (8/2012): Record extension methods and analyses are currently (8/2012) underway.

2d. Examine record-extension results for reasonableness of fit.

Work has not begun (9/2011).

Update (8/2012): Record extension methods and analyses are currently (8/2012) underway.

2e. Table record-extension results and accompanying documentation.

Work has not begun (9/2011).

Update (8/2012): Record extension methods and analyses are currently (8/2012) underway.

3a. Identify long-term unregulated stations to serve as regional index stations for systematic tracking of stationarity of flood frequency data.

Several long-term unregulated stations, or index stations, have been identified for systematic tracking of stationarity. Additional stations may be included as index stations once the GIS database of dams is complete and can be used to evaluate regulation impacts.

No update (9/2011).

No update (8/2012).

3b Conduct statistical analyses of temporal variability in peak flows for regional index stations.

Work has not begun (9/2011).

Work has not begun (8/2012).

3c Investigate emerging methods for addressing temporal variability in peak-flow analyses or nonstationary peak –flow records.

Work has not begun (9/2011).

Work has not begun (8/2012).

3d Construct figures and tables presenting results.

Work has not begun (9/2011).

Work has not begun (8/2012).

4a. Investigate occurrence of high-outlier peak flows in northwestern Montana and define mixed-population region

High-outlier peaks have been identified for all of the part 6 gages in Montana. These gages are not restricted to the northwestern region of Montana, as several gages have been identified in central and south-central Montana as having high-outlier peaks. While flood frequency analyses are just beginning in western Montana, many gages were previously identified in this region to have high-outlier peaks and previously analyzed using a mixed population analysis. Many of these gages will likely be identified for inclusion in the mixed-population region.

Update (9/2011): Stations with high-outlier peaks have been identified in much of northwestern Montana as well as central Montana along the Rocky Mountain Front. The high-outliers are most obvious along the North-Central Front Range; however evidence of the high-outlier peaks along the entire front indicate that the mixed-population region is more extensive than the region defined by Parrett and Johnson in WRIR 03-4308. Determination of what regions should be included in the mixed-population region is difficult to determine as the high-outliers vary with drainage areas, location, and relative distance from the Front Range. Currently, different explainable variables are being investigated to determine which gages, or drainage basins, should be included in the mixed-population analyses. Large flood events help to further define those regions and the 2011 floods will help to determine these possible boundaries.

No update (8/2012).

4b. Investigate relative probability of occurrence of independent ordinary peak flows and high-outlier peak flows.

Determination of independent ordinary peak flows and high-outlier peak flows has not begun. Flood frequency analyses for all gages will be completed before this task will begin.

No update (9/2011).

No update (8/2012).

4c. Construct normalized high-outlier peak-flow probability distribution.

Work has not begun (9/2011).

Work has not begun (8/2012).

5. Quarterly progress reports.

A progress report detailing work completed from project inception to December 2010 was completed and emailed to cooperators on January 24, 2011.

Update (9/2011): A progress report detailing work completed from January through March 2011 was completed and email to cooperators on April 7, 2011.

Update (8/2010): A progress report detailing work completed from April through September 2011 was completed and emailed to cooperators on November 9, 2011.

III. Future activities

Given the opportunity to utilize the 2011 flood data to enhance the flood frequency analyses; the funding provided from USGS headquarters for data analyses; and the flood-related delays to the current scope of work, the Montana Water Science Center would like to amend the existing scope of work for the flood frequency analyses to included data through 2011. While the inclusion of this data will delay the final product approximately one year, the additional funding from USGS headquarters is expected cover the additional work. Table 2 is a timeline for a revised scope which would include peak-flow data through 2011.

Update (8/2012). The scope of work for this project was amended in December 2012.

Table 1. Project schedule by task

Work tasks	Milestone dates	FY2011			FY2012												FY2013											
		J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Project commencement	07/15/10																											
1. Conduct and document standard log-Pearson III flood frequency analyses for about 650 USGS gaging stations					X	X	X	X	X	X	X	X	X															
1a. Document regulatory structures that influence peak flows at gaging stations					X	X	X																					
1b. Construct table of regulating structures and stations influenced					X	X	X																					
1c. Retrieve and format peak-flow data								X	X																			
1d. Perform flood-frequency analyses									X	X	X	X																
1e. Construct figures and tables of frequency results and accompanying documentation										X	X	X																
2. Investigate application of record-extension methods for improving flood-frequency estimates for short-term gaging stations					X	X	X	X	X	X	X	X	X	X	X													
2a. Identify gaging stations with less than 15 years of record or with longer periods of record but substantially influence by unusual climatic conditions					X	X	X																					
2b. Conduct correlation analyses to determine appropriate index stations									X	X	X																	
2c. Conduct Bulletin 17b 2-station analyses and MOVE.1 analyses for record extension										X	X	X	X	X	X													
2d. Examine record-extension results for reasonableness of fit											X	X																
2e. Table record-extension results and accompanying documentation												X	X	X	X													
3. Initiate systematic tracking of stationarity of flood-frequency data for Montana					X	X	X	X	X	X	X	X																
3a. Identify long-term unregulated stations to serve as regional index stations					X	X																						
3b. Conduct statistical analyses of temporal variability in peak flows for regional index stations							X	X	X	X	X	X																
3c. Investigate emerging methods for addressing temporal variability in peak-flow analyses or nonstationary peak-flow records												X	X															
3d. Construct figures and tables presenting results													X	X														
4. Investigate application of regional mixed-populations analyses for Montana					X	X	X	X	X	X	X	X	X	X	X	X	X	X										
4a. Investigate occurrence of high-outlier peak flows in northwestern Montana and define mixed-population region					X	X	X	X																				
4b. Investigate relative probability of occurrence of independent ordinary peak flows and high-outlier peak flows								X	X	X	X	X	X	X	X													
4c. Construct normalized high-outlier peak-flow probability distribution													X	X	X	X	X	X										
4d. Conduct regional mixed-population frequency analyses for northwestern Montana gaging stations																	X	X	X									
4e. Construct figures and tables presenting results																			X	X	X							
5. Quarterly progress reports					X			X			X			X			X			X			X				X		
6. Report preparation																	X	X	X	X	X	X	X	X	X	X		
6a. Prepare draft tables and figures																	X	X	X									
6b. Prepare draft text and submit draft report	03/31/13																		X	X	X	X						
6c. Review and address comments; prepare for publication																						X	X	X	X			
6d. Submit final report	07/30/13																								X			