RESEARCH PROGRAMS USE ONLY
RESEARCH TOPIC STATEMENT NO: 15-015
DATE OF RECEIPT: 5/5/15

RESEARCH PROGRAMS

RESEARCH TOPIC STATEMENT

I. TITLE (required):

Regional Regression Equations Based on Channel-Width Characteristics to Estimate Peak-Flow Frequencies at Ungaged Sites in Montana Using Data through Water Year 2011

II. TOPIC STATEMENT (required):

The purpose of this research is to develop regional regression equations for the eight hydrologic regions of Montana using channel-width characteristics. Additionally, this research will develop and evaluate the use of aerial photography to estimate channel widths. Channel-width characteristics can be used on-site to quickly estimate frequencies and when weighted with regression equations based on basin characteristics, can be used to reduce uncertainty in frequency estimates. Parrett and Johnson (2004) previously developed regression equations using data through 1998 and channel width data that had been collected and maintained by the U.S. Geological Survey (USGS) through previous hydrologic and hydraulic studies.

Frequency estimates have been developed for 725 gaging stations in and near Montana (Sando and others, 2015a), of which approximately 540 gaging stations were used to develop regional regression equations based on basin characteristics (Sando and others, 2015b). Of these 540 gaging stations, nearly 100 do not have associated channel-width measurements. Channel-width characteristics, such as bankfull- and active-channel widths, are measured at a site of interest using appropriate field methodologies. Research activities in the proposed project will focus on measuring channel widths for gaging stations used in the regional regression equations and developing equations based on channel-width data. Additionally the USGS will evaluate the station basin and frequency characteristics to provide administrative guidance for managing the existing crest-stage gage network cooperatively operated by USGS and Montana Department of Transportation (MDT).

III. BACKGROUND STATEMENT (required):

The USGS publishes frequency estimates and methods for estimating frequencies at ungaged sites that are used for economical design of water conveyance and storage structures such as culverts, bridges, storm sewers, dams, and levees. Reliable frequency information also is crucial for effective planning and management of water resources and floodplains, to protect lives and property in flood-prone areas, and for determination of actuarial flood-insurance rates. For several applications, including Federal

Emergency Management Agency (FEMA) 100-year floodplain delineation and U.S. Department of Transportation Federal Highway Administration bridge and culvert design, USGS frequency estimates and methods generally are required.

Regional regression equations to estimate frequencies at ungaged sites in Montana are of particular value to the Montana Department of Transportation (MDT) because they serve as the basis of hydrologic analyses for road structures with design criteria dependent on flood characteristics. The USGS in cooperation with MDT and Montana Department of Natural Resources and Conservation compiled peak flow data and peak-flow frequency estimates at 725 gaging stations in Montana based on data through Water Year 2011 (Sando and others, 2015a). Approximately 540 of these gaging stations were used to develop regional regression equations to estimate frequencies at ungaged sites using GIS-based basin characteristics (Sando and others, 2015b). In addition to regression equations developed using basin characteristics; previous studies in Montana (Parrett and Johnson, 2004) also developed regional regression equations based on channel-width characteristics. Channel-width characteristics, particularly active- and bankfull channel widths, are formed by the flood regimen of a stream. Regression equations based on channel-width characteristics can be used on-site to quickly estimate frequencies and, when weighted with regression equations based on basin characteristics, can be used to reduce uncertainty in frequency estimates.

IV. RESEARCH PROPOSED (required):

The primary objectives of the proposed project include:

1) Perform site visits for approximately 73 active gaging stations to measure active-channel and bankfull-channel widths. Of the 73 gaging stations, the channel-width measurements for 41 gaging stations will be newly collected data, and the measurements for 32 gaging stations will be used to compare with previously collected data (Parrett and Johnson, 2004).
2) Measure channel widths using aerial photography for gaging stations which are used in the most recent regional regression equations (Sando and others, 2015b).
3) Develop regional regression equations to estimate frequencies at ungaged sites using channel-width data. Provide methods for weighting frequency estimates based on channel widths with frequency estimates based on basin characteristics.
4) Evaluate gaging station basin and frequency characteristics to provide administrative guidance for managing the existing crest-stage gage network cooperatively operated by USGS and MDT.

V. IT COMPONENT (required): Identify if the project includes an IT component (purchasing of IT hardware, development of databases, acquisition of existing applications, etc) or not. If so, describe IT component in as much detail as possible.

The USGS already has the required IT components in place to perform this study. Regional regression equations will be developed using the Weighted-Multiple-Linear Regression Program (WREG) which was developed by the USGS and is freely available at http://water.usgs.gov/software/WREG/. In addition to providing the data and regression equations in a final report, the USGS will make the equations and data available through StreamStats, a Web-based Geographic Information Systems application (http://water.usgs.gov/osw/streamstats/) that provides streamflow statistics for gaged sites and applications for estimating streamflow statistics at ungaged sites using previously developed regression equations.

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VI. URGENCY AND EXPECTED BENEFITS (required): This section must include a description of how this research will serve the public by providing a transportation system and services that emphasize quality, safety, cost effectiveness, economic vitality and/or sensitivity to the environment.

Regional regression equations to estimate frequencies based on channel-width characteristics will allow for field estimation of frequencies and can reduce uncertainty when weighted with basin characteristic based regression equations. These regression equations will meet critical needs for numerous structure-design and floodplain-management issues in Montana, especially for MDT.

The final report of this study will provide detailed documentation of methods, which will be of substantial value to MDT and other users in defending design flows and performing auxiliary analyses. This work also will update the channel-width characteristics database and might substantially streamline the process of measuring channel widths, and facilitate the use of channel-width regression equations.

Specific benefits to MDT and the taxpayer include:

- Economical hydraulic design. Updating and publishing the channel-width regression equations will allow MDT to use the most current hydrologic methodology based on recent data and will:
  - – Assist designers in accurately selecting proper culvert sizes and bridge openings, and reduce the risk of over- or under-sizing.
  - – Reduce construction costs that result from oversized culverts and bridge openings based on outdated hydrologic data.
- Establishment of road grades and low beam elevations. Setting road grades is predicated upon establishment of accurate flood elevation data. Updated channel-width regression equations will allow MDT staff to more confidently provide the appropriate level of service to the road user, and evaluate risks to the road facility and upstream properties during flood events.
- Defending against lawsuits. It is important to be able to technically justify the specific frequency estimates used in various design applications. Design flows based on up-to-date data and methods are defensible and reduce the risk of costly litigation.
- Transportation Safety: Under-design of current or future infrastructure projects as well as under-design of existing infrastructure due to changes in watershed or land use characteristics (e.g., climate, post fire, urbanization) has the potential to put create a safety hazard for the public. Reliable flood frequencies are required to mitigate these hazards.
- Stream restoration and fish passage. MDT projects sometimes require stream relocation and/or mitigation to reduce environmental impacts and allow fish passage. The design and implementation of mitigation activities requires up-to-date data and hydrologic methods that can withstand review by other agencies.
- Preliminary-engineering and planning process. Up-to-date data and hydrologic methods will allow MDT to make good planning level decisions and preliminary engineering cost estimates for system facility upgrades or reconstruction efforts.

Potential consequences of not updating the channel-width regression equations include:

– **Under-design**, resulting in either flood or road damage, or **over-design**, resulting in unnecessary capital expenditures based on outdated analysis.

– Inability to defend against damage claims and lawsuits resulting from flood damage with potential substantial cost of fixing an existing problem or paying damage claims.

– Falling further behind in analyzing hydrologic data that is being collected annually by USGS in cooperation with MDT.

VII. IMPLEMENTATION PLAN (required): Identify MDT office or entity outside of MDT responsible for implementation. Describe initial implementation plan, include timeframe for implementation.

All of the proposed work will be conducted by USGS. MDT involvement primarily will include review of the draft report for technical content. Periodic consultation with MDT will be conducted. Project commencement is scheduled for July 15, 2015. Proposed field work will be conducted during the summer months of 2015 and 2016. The final report will be completed by June 30, 2017.

	SFY 2015												SFY 2016											
	FFY 2015			FFY 2016												FFY 2017								
Work tasks	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
Project commencement	X																							
1. Conduct at-site channel measurements for 73 sites	X	X	X	X								X	X	X	X									
2. Develop and use remote methods to measure channel widths	X	X	X	X	X	X								X	X	X								
3. Develop regional regression equations																X	X	X	X					
4. Perform evaluation of peak flow data for administrative purposes related to crest-stage gage program							X	X	X	X	X	X												
5. Quarterly progress reports				X			X			X			X			X			X			X		
6. Report preparation																				X	X	X	X	X

The proposed study will produce the following:

- Quarterly progress reports
- Draft report for review prior to publication
- Final report
- Various conference presentations and final presentation to MDT

As work progresses on the proposed study, preliminary results will be made available to MDT for review on a provisional basis to allow timely application of study results.

The final report will be a USGS Scientific Investigations Report available on-line. Data presented will include the measured channel width data and final regression equations for the eight hydrologic regions of Montana. The report also will document the results of using aerial photography to measure channel widths and, if applicable the resulting regressions based on the remotely measured channel widths. The channel width data and regression equations will also be available in StreamStats. StreamStats is a Web-based Geographic Information Systems application that was developed through a cooperative effort of the USGS and ESRI, Inc. StreamStats provides streamflow statistics for gaged sites and allows users to quickly estimate streamflow statistics at ungaged sites using previously developed regression equations and basin characteristics deployed in StreamStats. The StreamStats home page can be found here: http://water.usgs.gov/osw/streamstats/index.html

The results of the CSG network evaluation will be provided internally to both the USGS and MDT for making administrative decisions regarding future changes to the ongoing CSG program that has been cooperatively operated by USGS and MDT since 1955. These results will not be formally included in a USGS report.

VIII. SUBMITTED BY: (required)

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IX. CHAMPION (optional): Must be internal to MDT, feel strongly that the research will benefit the Department, and is willing to chair the technical panel.

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X. SPONSOR(S) (optional): Must be internal to MDT (Division Administrator or higher) and willing to ensure implementation occurs, as appropriate.

NAME(S)_____
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Note: Submitter may attach continuation sheets if necessary. All research topics submitted become public property and submitters are not guaranteed to receive a contract for any work resulting from any submitted research topic.

XI. REFERENCES CITED

Parrett, Charles, and Johnson, 2003, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, appendix, 48 p.

Sando, S.K., McCarthy, P.M., and Dutton, D.M., 2015a, Peak-flow frequency analyses and results based on data through water year 2011 for selected streamflow-gaging stations in or near Montana: U.S. Geological Survey Scientific Investigations Report 2015-XXXX, xx p.; in review.

Sando, Roy, Sando, S.K., McCarthy, P.M., and Dutton, D.M., 2015b, Methods for estimating peak-flow frequencies at ungaged sites in Montana based on data through water year 2011: U.S. Geological Survey Scientific Investigations Report 2015-XXXX, xx p.; in review.