INTERAGENCY AGREEMENT	1. IAA NO. NRC-HQ-60-15-I-0006/M0003	PAGE 1 OF 11

2. ORDER NO.	3. REQUISITION NO. RES-17-0046	4. SOLICITATION NO.
5. EFFECTIVE DATE	6. AWARD DATE	7. PERIOD OF PERFORMANCE 09/14/2015 TO 12/31/2017

8. SERVICING AGENCY
GEOLOGICAL SURVEY UNITED STATES DEPT OF
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9. DELIVER TO
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MAIL PROCESSING CENTER
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USA

10. REQUESTING AGENCY
ACQUISITION MANAGEMENT DIVISION
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US NUCLEAR REGULATORY COMMISSION
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11. INVOICE OFFICE
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12. ISSUING OFFICE
US NRC - HQ
ACQUISITION MANAGEMENT DIVISION
MAIL STOP TWFN-5E03
WASHINGTON DC 20555-0001

13. LEGISLATIVE AUTHORITY
Energy Reorganization Act of 1974

14. PROJECT ID

15. PROJECT TITLE
SEE BLOCK 18.

16. ACCOUNTING DATA
N/A

17. ITEM NO	18. SUPPLIES/SERVICES	19. QUANTITY	20. UNIT	21. UNIT PRICE	22. AMOUNT
	PROJECT TITLE: Development of Guidance on Application of State of-Practice Flood Frequency Analysis Methods and Tools to Nuclear Power Plants Master IAA: N/A The purpose of this modification is to 1) modify the Statement of Work; 2) extend the period of performance end date from August 31, 2017 to December 31, 2017; 3) increase the level of effort by 474 hours from 1,486 to1,960 hours; and 4) increase the ceiling by $52,431 from $195,269 to $247,700. A detailed description is provided Continued ...				

23. PAYMENT PROVISIONS

24. TOTAL AMOUNT $0.00

25a. SIGNATURE OF GOVERNMENT REPRESENTATIVE (SERVICING) [signature]

25b. NAME AND TITLE Robert R. Mason, Chief, OSW/USGS

25c. DATE 1/5/17

26a. SIGNATURE OF GOVERNMENT REPRESENTATIVE (REQUESTING) [signature]

26b. CONTRACTING OFFICER JERRY PURCELL

26c. DATE 12/23/2016

TEMPLATE - ADM001 SUNSI REVIEW COMPLETE JAN 13 2017 ADM002 on the following pages.

Section B. STATEMENT OF WORK is hereby deleted in its entirety and is replaced with the following:

SECTION B. STATEMENT OF WORK

NRC Agreement Number NRC-HQ-60-15-1-0006	NRC Agreement Modification Number	NRC Task Order Number (If Applicable)	NRC Task Order Modification Number (If Applicable)
Project Title Development of guidance on application of state-of-practice flood frequency analysis methods and tools to nuclear power plants			
Common Cost Center Code 11-6-213-1014	**B&R Number**	**Servicing Agency** U.S. Geological Survey	
Principal Investigator : - Name Timothy Cohn - Address U.S. Geological Survey, Reston, Virginia, USA - Phone 703- 395-0204 - Email tacohn@usgs.gov			
NRC Requisitioning Office Office of Research			
NRC Form 187, Contract Security and Classification Requirements ☐ Applicable ☒ Not Applicable	☐ Involves Proprietary Information ☐ Involves Sensitive Unclassified		
☒ Non Fee-Recoverable	☐ Fee-Recoverable (If checked, complete all applicable sections below)		
Docket Number (If Fee-Recoverable/Applicable)	**Inspection Report Number (If Fee Recoverable/Applicable)**		
Technical Assignment Control Number (If Fee-Recoverable/Applicable)	**Technical Assignment Control Number Description (If Fee-Recoverable/Applicable)**		

1 - BACKGROUND

Regulatory Context:

The U.S. Nuclear Regulatory Commission (NRC) has developed regulations regarding the siting and design of nuclear power plants (NPPs) aimed at providing safety from various natural hazards, including flooding. Design criteria for nuclear power plants with respect to natural hazards are provided in the appropriate sections of 10 CFR Part 50, and Part 52. IOCFR Part 100 addresses siting criteria.

The regulatory criterion for protection of structures, systems, and components (SSCs) important to safety against natural phenomena is provided in 10 CFR Part 50 Appendix A, General Design Criterion (GDC) 2 "Design bases for protection against natural phenomena". GDC-2 states that SSCs important to safety shall be designed to withstand the effects of natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated. The regulation also states that the design bases shall reflect appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena.

The requirements for the contents of applications for new reactors is provided in 10 CFR Part 52, more specifically 10 CFR Part 52.17(a)(l)(vi), for early site permits (ESPs) and 10 CFR Part 52.79 (a)(l)(iii), for combined licenses as they relate to the hydrologic characteristics of the proposed site with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

Reactor site criteria are provided in 10 CFR Part 100. The requirements to consider physical site characteristics (including hydrologic features) in site evaluations are specified in 10 CFR Part 100.lO(c) for applications before January 10, 1997, and 10 CFR Part 100.20(c) for applications on or after January 10, 1997.

NRC regulatory guidance for flood hazard assessments currently focuses on using deterministically derived, conservative estimates of key flood causing mechanisms (e.g. Probable Maximum Precipitation, Probable Maximum Flood) to provide the "sufficient margin" called for in the regulations. The magnitude of the provided margin is not explicitly quantified in either a physical or risk sense.

Probabilistic treatment of flood hazard phenomena can provide quantitative estimates of the flood safety margin and thus contribute to the risk-informed assessment of flooding hazards, but regulatory guidance on the use of probabilistic methods for riverine flood hazard assessment at nuclear power plant sites is lacking.

This research project is part of the NRC's Probabilistic Flood Hazard Assessment (PFHA) Research plan. The proposed work will aid development of guidance on the use of PFHA methods and support risk- informing NRC's licensing framework (flood hazard design standards at proposed new facilities as well as significance determination tools for evaluating potential deficiencies related to flood protection at operating facilities). The tools and guidance developed will support and enhance NRC's capacity to perform thorough and efficient reviews of license applications and license amendment requests. They will also support risk-informed significance determination of inspection findings, unusual events and other oversight activities.

Technical Context:

Hydrological processes such as riverine flooding exhibit substantial variability that cannot be adequately described by deterministic application of physical laws. Uncertainty in modeling riverine flooding processes arises from: 1) inherent randomness in drivers such as rainfall and physical features of the watershed; 2) sampling errors; and 3) incomplete understanding of the hydrologic processes involved. Therefore statistical and probabilistic modeling approaches are often used, in combination with process- based understanding, to develop insights into the expected magnitude and variability of future observations and to estimate design floods.

Flood frequency analysis is a statistical method used to estimate design floods for sites along a river that uses observed peak flow discharge data (usually annual maximums) to calculate statistical information such as mean values, standard deviations, skewness, and recurrence intervals. These statistical data are then used to construct frequency distributions, which are curves that estimate the likelihood of various discharges as a function of average recurrence interval (in years) or annual exceedance probability (i.e., the probabilities of floods of various sizes can be extracted from the curve). Where long historical flow records are available at a site, the flood frequency curve can be estimated using flood peak data from the site alone. More commonly, where the site is either ungauged or has insufficient flow records, the flood frequency curve is estimated using data collected from a group of similar sites.

The principal advantage of the flood frequency analysis approach isthat extrapolation can be made of the values for events with return periods beyond the observed flood events. At the same time, choice of probability distribution, the validity of extrapolations and estimation of their uncertainty are challenging issues. A number of basic assumptions underlying flood frequency analysis are often partially or completely violated. For example, flood frequency analysis is commonly based on the assumption that flood flows are independent and identically distributed random variables.In reality, the probability distribution of floods can change in time (i.e., exhibit non-stationarity) as a result of local human activities, such as land use changes or reservoir operations, or regional or global climate change.

Even if stationarity is present, the complex relationships between precipitation, watershed reaction, and other factors can result in observed peak flow distributions created by population mixing. For example, spillage from a reservoir in a tributary of a river system can create substantially larger peak discharge in the mainstem depending on joint probability of both large discharge from a tributary simultaneous with arrival of the flood event along the mainstem.

A plethora of distribution functions and estimation methods are available for developing flood frequency curves (Kite 1977, Stedinger, Vogel et al. 1993). This situation prompted the Hydrology Subcommittee of the Interagency Advisory Committee on Water Data (IACWD) to develop Bulletin 17B, "Guidelines for Determining Flood Flow Frequency" (B17B, IACWD 1982), in order to promote a consistent approach to flood-flow frequency determination among federal,state, and local agencies. IACWD was superseded by the Interagency Advisory Committee on Water Information (ACWI) in 1996. Recently, the ACWI Subcommittee on Hydrology (ACWI/SOH) chartered the Hydrologic Frequency Analysis Work Group (HFAWG) to update the guidelines and draft an updated document (Bulletin 17C, or Bl7C).

Because the intent of B17B (and B17C) is to promote consistency in flood frequency determinations for common applications (e.g. defining flood hazard-hazard areas and flood plains, and for designing bridges, culverts, dams, levees, and other flood-control structures) a single probability distribution and a single estimation method are used. For example, B17B specifies that annual peak-flow data are to be fit to a log-Pearson Type III distribution. B17B also prescribed specific methods for using regional skew information, tests for high and low outliers, adjustments for low outliers and zero flows, and procedures for incorporating historical flood information. The consensus in the flood hydrology community is that flood frequency curves derived using B17B (and Bl7C} methods are reliable for average return intervals (ARI} ranging from 100-500 years for typical sites and observation sources. This corresponds to annual exceedance probabilities (AEPs) in the range 0.01to 0.005. However, this range is considerably higher than that of the extreme floods often used in the design, licensing, and oversight of nuclear power plants. Moreover, there is a lack of guidance on use of conventional flood frequency methods and extrapolation of derived flood frequency curves for nuclear power plant licensing and oversight applications.

This project will provide guidance for NRC staff on state of practice methods in flood frequency analysis and the application of such methods to nuclear power plant licensing and oversight. The focus will be on best practices for characterizing the full uncertainty in flood frequency estimation, and providing guidance on judging the validity of extrapolating hydrologic hazard curves to the range of interest for nuclear power plant applications. Guidance on the use of methods advocated in Bulletin 17B (and Bulletin 17C as it becomes available) for nuclear power plant applications will be provided, but the project will not be limited to only these methods.

The focus of this project is to develop and provide guidance to NRC staff on the established methods of flood frequency analysis. Another PFHA project titled "Technical basis for extending frequency analysis beyond current consensus limits" will investigate more innovative probabilistic methods, in combination with other data (e.g. precipitation), to extend the hydrologic hazard curves into the range of return periods potentially required for use in nuclear power plant probabilistic risk assessments.

2. OBJECTIVE

The objective of this Agreement is for U.S. Geological Survey (USGS) to develop guidance on application of state-of-the-practice flood frequency methods and tools, especially for assessing the

credible limit for extrapolation of riverine flood hazard information developed using these methods and tools.
Knowledge transfer and training for NRC staff to guide in performing frequency analysis for sites with varying degree of stream flow data availability (i.e., at site, historical, or paleoflood data) and characteristics (i.e., stationary vs. non-stationarity) are also important objectives of this project.

3. SCOPE OF WORK

The following list provides the general scope of work (SOW) under this project. To accomplish the objectives of this project the USGS will:

1. Provide guidance on application of flood frequency analysis using only at-site instrumental stream flow data and historical records. [Prepare a USGS Report summarizing activity 1.]
2. Provide guidance on application of flood frequency analysis using at-site instrumental stream flow data and historical records in combination with regional instrumental data and/or paleoflood information.
3. Provide guidance on application of flood frequency analysis for stream flow data exhibiting non-stationary characteristics. [Prepare a USGS Report summarizing activity 2 & 3.]
4. Conduct a training seminar at the NRC Headquarters in Rockville, MD covering the topics in items 1-3.
5. Prepare NUREG-CR Report summarizing activities 1-3 and providing guidance on use of state-of-practice flood frequency methods and tools for nuclear power plant licensing and oversight applications.

With the exception of providing the venue for the training seminar listed in item 4 above, USGS must provide all resources necessary to accomplish the tasks and deliverables described in this SOW.

4. SPECIFIC TASKS

The following section describes the specific tasks under this task order. To accomplish the objectives of this project the USGS shall:

Task 4.1: Develop guidance on flood frequency analysis using at-site data (25% of effort)

USGS shall provide guidance on application of state-of-practice flood frequency analysis methods and tools to using at-site instrumental stream flow data and historical records.

a) In consultation with NRC Contracting Officer Representative (COR), select a riverine site within the conterminous U.S. (CONUS} with available at-site instrumental stream flow data and historical records that is suitable for illustrating the strength and weakness of state-of-practice methods and tools. If feasible and appropriate, it is desirable that the site selected be the same site as that used in Task 2 (described below), in order to illustrate how regional and/or paleoflood information can improve reliability of flood frequency estimates. In that case, this task would only use the at-site and historical information.

b) Develop example frequency analyses using several state-of-practice methods (including B-17B or B-17C methods as appropriate). The focus will be on best practices for characterizing the full uncertainty in flood frequency estimation, and providing guidance on judging the validity of extrapolating hydrologic hazard curves to the range of interest for nuclear power plant applications.

Deliverable: USGS Report

Task 4.2: Develop guidance on flood frequency analysis using regional data (25% of effort)

USGS shall provide guidance on application of state-of-practice flood frequency analysis methods and tools to using regional and paleoflood information in addition to at-site instrumental stream flow data and historical records.

a) In consultation with the NRC COR, select a CONUS riverine site with available at-site instrumental stream flow data, historical records, regional data and paleoflood information that is suitable for illustrating the strength and weakness of state-of-practice methods and tools for regional flood frequency analysis. If feasible and appropriate, it is desirable that the site selected be the same site as that used in Task 1 (described above), in order to show how incorporating regional and/or paleoflood information can improve reliability of flood frequency estimates relative to using only at-site information. In that case, this task would use all the available at-site, historical, regional and paleoflood information.

b) Develop example frequency analyses using several state-of-practice methods (including B-17B or B-17C methods as appropriate). The focus will be on best practices for characterizing the full uncertainty in flood frequency estimation, and providing guidance on judging the validity of extrapolating hydrologic hazard curves to the range of interest for nuclear power plant applications.

Deliverable: Front Matter draft of Second USGS Report (Introduction, Literature Review, Methods)

Task 4.3: Develop guidance on flood frequency analysis under non-stationarity (25% of effort)

USGS shall provide guidance on application of state-of-practice flood frequency analysis methods and tools to a site with stream flow data exhibiting non-stationary characteristics owing to:

a) Land use or land cover change;
b) Flow regulation due water control structures such as dams;
c) Changes in stream flow due to change in climate system (i.e., change in precipitation amounts and/or frequency)

As with the previous tasks, selection of site(s) to use for illustration of methods shall be conducted in consultation with the NRC COR. More than one site may be needed to cover all of the causes contributing to nonstationarity listed above. As with the previous tasks, the focus will be on best practices for characterizing the full uncertainty in flood frequency estimation, and providing guidance on judging the validity of extrapolating hydrologic hazard curves to the range of interest for nuclear power plant applications.

Deliverable: Complete draft of Second USGS Report (Example Site, Results, Discussion, Conclusion)

Task 4.4: Training Seminar for the NRC Staff (12% of effort)

USGS shall transfer knowledge developed in Tasks 1, 2, and 3 to the NRC staff by conducting a training seminar at the NRC headquarters in Rockville, MD. The seminar will demonstrate application of techniques and results of the analysis for examples in Tasks 1-3 and provide step by step guidance on the implementation method for future use by NRC staff.

The training seminar will span two business days and will include lecture, computer lab exercises and discussion. USGS shall provide the materials for the seminar in paper and electronic format.

Deliverable: Training Seminar

Task 4.5: Preparation of NUREG-CR Report (13% of effort)

Based on the work in Tasks 1-3, USGS shall prepare an NRC contractor report (NUREG-CR). USGS shall organize a peer review of the report using one or two experts from outside of the organization performing the work of this project. The NRC COR must approve the selection of peer reviewers. Following the peer review, USGS shall prepare a final report to be delivered to the NRC.

Deliverable: NUREG-CR Report

5. DELIVERABLES SCHEDULE

The main project deliverables will be monthly letter status reports (MLSRs), reports and, webinars summarizing results of Tasks 1-3 as each task is completed, the training seminar described in Task 4, and a NUREG/CR report summarizing the results of the complete project. It is expected that the NUREG/CR report will be based mainly on the contents of the letter reports. NRC will review and provide comments on the letter reports to the USGS as they are completed in order to ensure the timely completion of the NUREG/CR report.

Task Number	Deliverable/Milestone Description	Due Date
1	USGS shall provide the first Draft USGS Report. The NRC will review and provide comments on the Draft USGS after receipt of the draft USGS report.	NLT 6 months from the commencement of this agreement.
1	USGS shall provide the Finalized USGS Report	NLT 4 months after receipt of NRC comments on the Draft USGS Report
2	USGS shall provide the front matter of the second USGS Report. The NRC will review and provide comments on front matter of the second USGS Report after receipt of the draft letter report.	NLT 17 months from the commencement of this agreement .
3	USGS shall provide the complete draft USGS report covering tasks 2 and 3. The NRC will review and provide comments on the complete draft USGS report after receipt of the draft letter report.	NLT 20 months from the commencement of this agreement.
3	USGS must provide the Finalized Second USGS Report	NLT 2 months after receipt of NRC comments on the second Draft USGS Report
4	Training Seminar	NLT 24 months from the commencement of this agreement.
5	USGS shall provide a Draft NUREG-CR Report based on the USGS Reports. The NRC will review and provide comments on the Draft NUREG-CR Report after receipt of the draft NUREG-CR report.	NLT 26 months from the commencement of this agreement.

5	USGS shall provide a Final NUREG-CR Report	NLT 4 weeks after receipt of NRC comments on the Draft Letter Report
	USGS shall submit a Monthly Letter Status Report	NLT 20th of each month

6. TECHNICAL AND OTHER SPECIAL QUALIFICATIONS REQUIRED

The work to be performed in this project requires significant expertise and experience in the following areas: 1) hydrology 2) riverine flooding, 3) probability and statistical theory, and 4) probabilistic and statistical analysis of stream flows. Experience with the analyzing datasets for observed stream flows is essential. Experience in flood frequency analysis including regional analysis and use of paleoflood data is required. USGS shall demonstrate that their staff has the technical ability to perform the tasks outlined in this SOW. Generally, this ability would be a doctorate or equivalent in a relevant science or engineering discipline (e.g., hydrology, water resources engineering). A demonstration of any combination of equivalent experience and/or education in the previously mentioned disciplines may be considered as meeting the technical qualifications.

7. LABOR CATEGORIES AND LEVEL OF EFFORT

		FY16	FY17	FY18	Total
Task Number	Estimated Labor Hours	Estimated Labor Hours	Estimated Labor Hours	Estimated Labor Hours	
1	PM/Sr Key Staff	80	120		200
1	PI	400	200		600
1	Key Staff	80	80		160
1	Support Staff	40	80		120
2	PM/Sr Key Staff		60		60
2	PI		80		80
2	Key Staff		100		100
2	Support Staff		80		80
3	PM/Sr Key Staff		60		60
3	PI		80		80
3	Key Staff		100		100
3	Support Staff		80		80
4	PM/Sr Key Staff			40	40
4	PI			40	40
4	Key Staff			40	40
4	Support Staff			40	40
5	PM/Sr Key Staff			20	20
5	PI			20	20
5	Key Staff			20	20
5	Support Staff			20	20
	Total	600	1120	240	1960

8. MEETINGS AND TRAVEL

The Principal Investigator (PI) shall make (up to two) four-day trips to meet with NRC staff at an Annual Workshop at NRC Headquarters in Rockville, MD.

The PI shall make a two-day trip to NRC Headquarters in Rockville, MD for the technology-transfer/training seminar and training session fisted under "Deliverables/Schedule".

The PI shall make (up to two) two-day trips to NRC Headquarters in Rockville, MD for project review meetings.

All travel requires written Government approval from the Contracting Officer's Representative. No foreign travel is authorized under this Agreement.

9. REPORTING REQUIREMENTS

Monthly Letter Status Report

A Monthly Letter Status Report (MLSR) shall be submitted to the NRC Contracting Officer Representative by the 20th of the month following the month to be reported with copies to the Contracting Officer (CO) and the Office of Administration Acquisition Management Division to ContractsPOT.Resource @nrc.gov.If a project is a task ordering agreement, a separate status report must be submitted for each task order with a summary project status report, even if no work has been performed during a reporting period.
Once NRC has determined that all work on a task order is completed and that final costs are acceptable, a task order may be omitted from the MLSR.

The servicing agency is responsible for structuring the deliverable to follow agency standards.The current agency standard is Microsoft Office Suite 2010. The current agency Portable Document Format (PDF) standard is Adobe Acrobat 9 Professional. Deliverables must be submitted free of spelling and grammatical errors and conform to requirements stated in this section.

10. PERIOD OF PERFORMANCE

The estimated period of performance for this work is September 1, 2015 to December 31, 2017.

11. CONTRACTING OFFICER'S REPRESENTATIVE

The COR monitors all technical aspects of the agreement/task order and assists in its administration. The COR is authorized to perform the following functions: assure that the servicing agency performs the technical requirements of the agreement/task order; perform inspections necessary in connection with agreement/task order performance; maintain written and oral communications with the servicing agency concerning technical aspects of the agreement/task order; issue written interpretations of technical requirements, including Government drawings, designs, specifications; monitor the servicing agency's performance and notify the servicing agency of any deficiencies; coordinate availability of NRC- furnished material and/or GFP; and provide site entry of servicing agency personnel.

Contracting Officer's Representative

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Alternate Contracting Officer's Representative

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E-Mail: Joe.Kanney@nrc.gov
Phone: 301-415-1920

12. MATERIALS REQUIRED

Not Applicable.

13. NRC-FURNISHED PROPERTY/MATERIALS

Not Applicable.

14. OTHER CONSIDERATIONS

Not Applicable.

15. REFERENCES

IACWD (1982). Guidelines for Determining Flood Flow Frequency: Bulletin 17B of the Hydrology Subcommittee of the Interagency Advisory Committee on Water Data (now Interagency Advisory Committee on Water Information, ACWI). Reston, VA, U.S. Department of the Interior, U.S. Geological Survey, Office of Water Data Coordination.

Kite, G. W. (1977). Frequency and Risk Analyses in Hydrology. Fort Collins, CO, Water Resources Publications.

Stedinger, J. R., R. M. Vogel and E. Foufoula-Georgiou (1993). Frequency Analysis of Extreme Events. Handbook of Hydrology. D. R. Maidment. New York, McGraw-Hill.