

**Susitna-Watana Hydroelectric Project
(FERC No. 14241)**

**Site-Specific Seismic Hazard Study
Study Plan Section 16.6**

**Part D: Supplemental Information to
June 2014 Initial Study Report**

Prepared for

Alaska Energy Authority



SUSITNA-WATANA HYDRO

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Prepared by

MWH

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1. INTRODUCTION

Section 1 (Part A) of the June 2014 ISR for this Site-Specific Seismic Hazard Study (Study Plan 16.6) details the development of this study from the Revised Study Plan (RSP) in 2012, through the end of the 2013 study season. Section 7 of the ISR (Part C), filed in June 2014, sets forth AEA's plan and schedule, at that time, for completing this study and meeting the objectives of the RSP.

As detailed in Section 2.2 of the ISR Part D Overview, various circumstances have required AEA to extend the original timeframe for completing the Commission-approved Study Plan. However, AEA has completed this Study 16.6 since the filing of the ISR in June 2014. As detailed below, AEA's recent activities for Study 16.6 have consisted of the following:

- The study team evaluated crustal seismic sources through review of newly acquired LiDAR imagery and based on geomorphic characteristics in the field and geologic relationships around the lineament feature in the Project area with an emphasis in the dam site area.
- The study team performed Interferometric Multichannel Analysis of Surface Wave measurements to estimate shear wave velocity in the Project area.
- The study team evaluated the surface fault rupture hazard in the dam site area, focusing in the possibility of displacement along existing planes of weakness in the bedrock.
- The study team performed field geologic transects to access geologic relationships and styles and patterns of structural deformation.
- The study team reviewed site-specific surface and subsurface investigations at the dam site.
- The study team established a geologic datum for evaluating tectonic (fault) activity during the late Quaternary; developed understanding of Quaternary geologic history.
- The study team monitored earthquake activity in the Project area to refine the intraslab model, checked the source characterization of background sources, defined focal mechanisms for larger detected earthquakes and documented the background level of seismicity to monitor reservoir triggered seismicity.
- The study team updated ground motion prediction equations and utilized updated source models for seismic hazard analysis.
- The study team developed preliminary seismic design criteria for the finite element analysis for the dam.
- On October 22, 2014, AEA held an ISR meeting for the Seismic Hazard Study.
- The study team prepared the Study Completion Report in October 2015.

The primary purpose of this Part D Supplemental Information to the ISR is to report on the implementation of the Study Plan from the filing of the ISR in June 2014, through the filing of this ISR Part D. In light of this additional implementation, AEA has now completed Study 16.6 in a manner that meets the objectives of the Commission approved Study Plan.

2. BACKGROUND

2.1. Purpose of Study

The goals of this study are to conduct deterministic and probabilistic seismic hazard evaluations to estimate earthquake ground motion parameters at the Project site, assess the risk at the site and the loads that the Project facilities would be subject to during and following seismic events, and propose design criteria for Project facilities and structures considering the risk level.

The study objectives are established in RSP Section 16.6.1:

- Identify the seismic sources along which future earthquakes are likely to occur, including the potential for reservoir-triggered seismicity;
- Characterization of the degree of activity, style of faulting, maximum magnitudes, and recurrence information of each fault;
- Develop maps and tables depicting the spatial and geometric relations of the faults and seismic source zones together with specific distance parameters to evaluate ground motion parameters from each source;
- Assemble available historical and instrumental seismicity data for the region, including maximum and minimum depth of events;
- Determine the distance and orientation of each fault with respect to the site;
- Estimate the earthquake ground motions at the proposed dam site, updating previous studies to include changes in practice and methodology since the 1980s;
- Propose the seismic design criteria for the site;
- Prepare a supporting design report that includes the seismic criteria and results of dam stability analysis under seismic loading (this will be addressed as part of the dam analysis, not as part of the initial seismic characterization); and
- Use of Board of Consultants for independent technical review and guidance during development of site-specific studies.

2.2. Study Components

The key study components of this study include:

- Review of scientific literature, Interferometric Synthetic Aperture Radar (INSAR) and Light Detection and Ranging (LiDAR) datasets.

- Lineament mapping and analysis in order to identify potential seismic hazards, field reconnaissance and mapping of potential fault features.
- Monitor and review of earthquake event data for the Project area.
- Obtain shear wave velocity measurements of bedrock.
- Develop a preliminary seismic hazard assessment (PSHA), including ground motions for design.

3. STATUS, HIGHLIGHTED RESULTS, AND ACHIEVEMENTS

In 2012-2013, prior to the filing of the ISR, several study components were initiated. The initial task to kick-off the seismic hazard assessment study was to conduct a desk top PSHA to update the 1980s seismic hazard assessment. With the acquisition of project Light Detection and Ranging (LiDAR) imagery, coupled with existing Interferometric Synthetic Aperture Radar (INSAR) digital data, lineament mapping and analysis was conducted to identify potential tectonic features. Field reconnaissance was conducted to inspect the landscape and geomorphic features to determine the origin of the lineament and to look for positive evidence for (or against) tectonic deformation.

The following tasks were completed in 2013 and reported in Part A of the June 2014 ISR for Study 16.6:

- In 2013, the long-term earthquake monitoring network which was established in fall 2012 was expanded. Three additional seismograph stations were installed, increasing the number of stations in the network to seven. In addition, a GPS station had been installed and co-located with a seismograph station near the dam site. The earthquake event data is being compiled and analyzed to characterize the seismic environment and seismic source model. At each of the seismograph sites, geophysical surveys were conducted to determine shear wave velocities in bedrock.
- Other tasks conducted included completion of a preliminary assessment of reservoir triggered seismicity study and utilization of the data collected to revise the intraslab seismic source model and to conduct a PSHA sensitivity study.

The study team has completed the following activities for Study 16.6 since the June 2014 filing of the ISR:

- Field inspection and evaluations of depicted or inferred nearby potential fault structures of crustal scale such as the Talkeetna Thrust, Susitna lineament, and Watana lineament to determine the origin of geomorphic features and if tectonic deformation of overlying or nearby Quaternary deposits has occurred.
- Surface fault rupture evaluation was performed in the dam site area and considered regional geologic history, sub-regional deformation patterns, observed Mesozoic and Cenozoic bedrock, emplacement of intrusions, volcanics, crustal stress orientations,

known active faulting, GPS data, geomorphic landform evaluations, and current understanding of geologic features at the dam site.

- Seismicity cataloging of earthquake events in the project area was continued – providing a better picture of shallow crustal seismicity and intraslab seismicity associated with the subducting Pacific Plate
- Focal mechanisms were identified for the large earthquakes detected by the Project long-term earthquake monitoring network.
- Crustal movement – an estimate of the rate of horizontal motion of the dam site, relative to the North American plate was made - is 9 mm/year westward, 3 mm/yr northward and 4 mm/yr upward.
- Response Spectra and time histories were developed for each type of event to evaluate the difference in frequency content.
- Seismic design criteria were developed using a deterministic seismic hazard analysis (DSHA), the maximum design earthquake (MDE) was defined, and the operating basis earthquake (OBE) was selected from the PSHA.
- Some of the study components, e.g., crustal seismic source evaluation, were continued and refined in 2014 and early 2015 as new data and results of analyses became available. Since the filing of the June 2014 ISR, significant progress has been made and resulted in the completion of the crustal seismic source evaluation including the surface fault rupture evaluation at the dam site, continued collection of earthquake event data by the long-term earthquake monitoring network, development of seismic design criteria for the engineering feasibility dam analyses, and technical review of the seismic hazard studies by the Board of Consultants.

4. SUMMARY OF STUDY 16.6 DOCUMENTS

Since filing of the RSP in 2012, AEA and FERC have prepared several documents pertaining to this study. To aid review by FERC staff and licensing participants, each of these documents is listed below. Each of these documents is accessible on AEA's Project licensing website (<http://www.susitna-watanahydro.org/type/documents/>) by clicking on the entry in the "Link" column in the table. In addition, these documents are available on FERC's eLibrary system (<http://www.ferc.gov/docs-filing/elibrary.asp>), in Docket No. P-14241.

Title	Date	Description	Link
16.6. Site-Specific Seismic Hazard Study (Revised Study Plan	12/14/2012	This document presents the plan this study, including goals, objectives, the study area, and proposed study methods for the Site-Specific Seismic Hazard Study.	RSP for Study 16.6
FERC Study Plan Determination for Study 16.6	2/1/2013	This document presents FERC approval of Study 16.6, which approved AEA's Revised Study Plan	FERC SPD for Study 16.6

		with no recommended adjustments.	
Draft Initial Study Report for Study 16.6	2/3/2014	This draft of the ISR summarized the study methods and variances during the 2013 study season, and presented preliminary data collected for 16.6. This draft ISR was later republished as Part A of the final ISR.	Draft ISR for Study 16.6
Initial Study Report for Study 16.6	6/3/2014	This document is the Initial Study Report (Parts A, B and C) for Study 16.6. Part A republishes the Draft ISR. Part B identifies supplemental information and errata in Part A. Part C presents study modifications and plans for completing the study.	ISR Part A for Study 16.6 ISR Part B for Study 16.6 ISR Part C for Study 16.6
Initial Study Report Meetings, October 22, 2014	11/14/2014	Transcripts and AEA's agenda and PowerPoint presentations for the ISR meeting concerning the Project Site-Specific Seismic Hazard Study.	Transcripts from ISR Meeting Materials from ISR Meeting
Site-Specific Seismic Hazard Study (16.6) – Study Completion Report	11/6/2015	Study Completion Report: a comprehensive presentation of all results for the study.	SCR for Study 16.6

5. NEW STUDY DOCUMENTATION SUPPLEMENTING THE ISR

The following table identifies and describes additional reports and other documents that update, refine, or otherwise supplement certain sections of the ISR pertaining to this Study 16.6, during AEA's continued implementation of the Study Plan since the ISR was filed in June 2014.

ISR Reference	Description
Part A, Section 4	This Section is updated and supplemented by the Study Completion Report for Study 16.6 (Section 4), which described the study methods and variances in 2014 and early 2015.
Part A, Section 5	This section is updated and supplemented by the Study Completion Report for Study 16.6 (Section 5), which described the study results in 2014 and early 2015.
Part A, Section 6	This section is updated and supplemented by the Study Completion Report for Study 16.6 (Section 6), which discusses the study results in 2014 and early 2015.
Part C, Section 7	The decision points and modifications in this section are updated and supplemented by the Study Completion Report for Study 16.6 (Section 7), which presents the decision points from 2014 and proposed modification after conducting studies in 2014 and early 2015.

6. VARIANCES

6.1. 2013 Study Season

The following variances are reported in the June 2014 ISR:

- Land access restrictions in 2013 limited ground studies on Cook Inlet Regional Working Group (CIRWG) lands. This restriction largely impacted ground field activities, (e.g. geologic mapping, shallow pits and sampling).

6.2. 2014 - 2015 Study Season

As noted in Section 4 of the Study Completion Report for this study, AEA encountered no variances when implementing this study in 2014-2015.

7. STUDY PLAN MODIFICATIONS

7.1. Modifications Identified in ISR

As detailed in Section 7 of the ISR (Part C), AEA plans no modifications of the methods for this study.

7.2. Modifications Identified since the June 2014 ISR

As detailed in the Study Completion Report for this study, AEA plans no modification of the methods for this study, as this study is now complete.

8. STEPS TO COMPLETE THE STUDY

The field work, data collection, data analysis, and reporting for this study successfully met all study objectives in the FERC approved Study Plan. In light of the results and variances described above, AEA has completed this study.