

Initial Study Report Meeting

Study 16.6 Site-Specific Seismic Hazard

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Study 16.6 Objectives

- Lineament mapping and analysis, desktop study and field evaluation
- 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 for D/PSHA
- 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 Project long-term monitoring network 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
- Prepare a supporting design report that includes the seismic criteria and results of dam stability analysis under seismic loading (see dam analysis, this is not part of the seismic characterization)
- Use of Board of Consultants for independent technical review and guidance during development of site-specific studies

Study 16.6 Components

- Methods (ISR Part A, Section 4.1; pg 2)
- Review of Project Documentation (ISR Part A, Section 4.1, pg. 3)
- Seismic Hazard Analysis (ISR Part A, Section 4.1, pg 3)
- Long-Term Earthquake Monitoring System (ISR Part A, Section 4.2; pg 4)
- Preliminary Reservoir Triggered Seismicity (ISR Part A, Section 4.3; pg 5)

Study 16.6 Variances

- Land access restrictions in 2013 limited ground studies on Cook Inlet Regional Working Group (CIRWG) lands. This restriction largely impacted on-the-ground field activities, (e.g., geologic mapping, shallow pits and sampling). Also new LiDAR imagery being obtained for other studies near the dam site area was not obtained because of weather. New field techniques were implemented to measure shear wave velocities.

Study 16.6 Summary of Results in ISR

(ISR Study 16.6, Part A – Section 5)

- Review of Project Documentation
 - Review geologic, geotechnical, and seismic conditions within the Project area from previous studies and research (WCC, 1980, 1982)
 - Contact technical experts in the Alaskan seismotectonics
 - Development of an initial geological and seismotectonics database and library.
- Preliminary PSHA
 - Updated seismic source model and attenuation relationships
 - Intraslab (subduction) event is likely be strongest contributor to site ground motions
 - Preliminary Ground Motion – Deterministic 0.53g, Probabilistic 0.66g @2,500 yrs.
- Crustal Seismic Source Assessment, Interim
 - Lineament mapping and analysis for fault studies using LiDAR and IFSAR data
 - Criteria were developed for determining significant crustal seismic source potential (e.g., rupture length and earthquake magnitude, length – distance criteria)
 - Many of the lineaments visited in 2013 are judged to be dominantly erosional in origin, or to a lesser extent, related to rock bedding or jointing, and are not evidently associated with tectonic faults

Study 16.6 Summary of Results in ISR

(ISR Study 16.6, Part A – Section 5)

- **Seismic Monitoring**

- Established seven-station long-term monitoring system, comprised of four 6-component broadband and strong motion seismographs, three broadband seismographs, and one GPS station at the proposed Watana Dam site.
- Recorded about 1,150 earthquakes per year which were located within a region roughly 50 miles east-west and 30 miles north-south.
- Earthquakes in the Project area form two distinct groups, crustal events between 0 and 16 mi depth and intermediate depth events below 19 mi in the subducting Pacific plate.
- Largest recent event, M_L 4.0, occurred on October 23, 2013 at a depth of 42.0 mi (67.6 km), with an epicenter 8.7 mi (~14 km) west-northwest of the proposed Watana Dam site.

- **Preliminary Reservoir Triggered Seismicity**

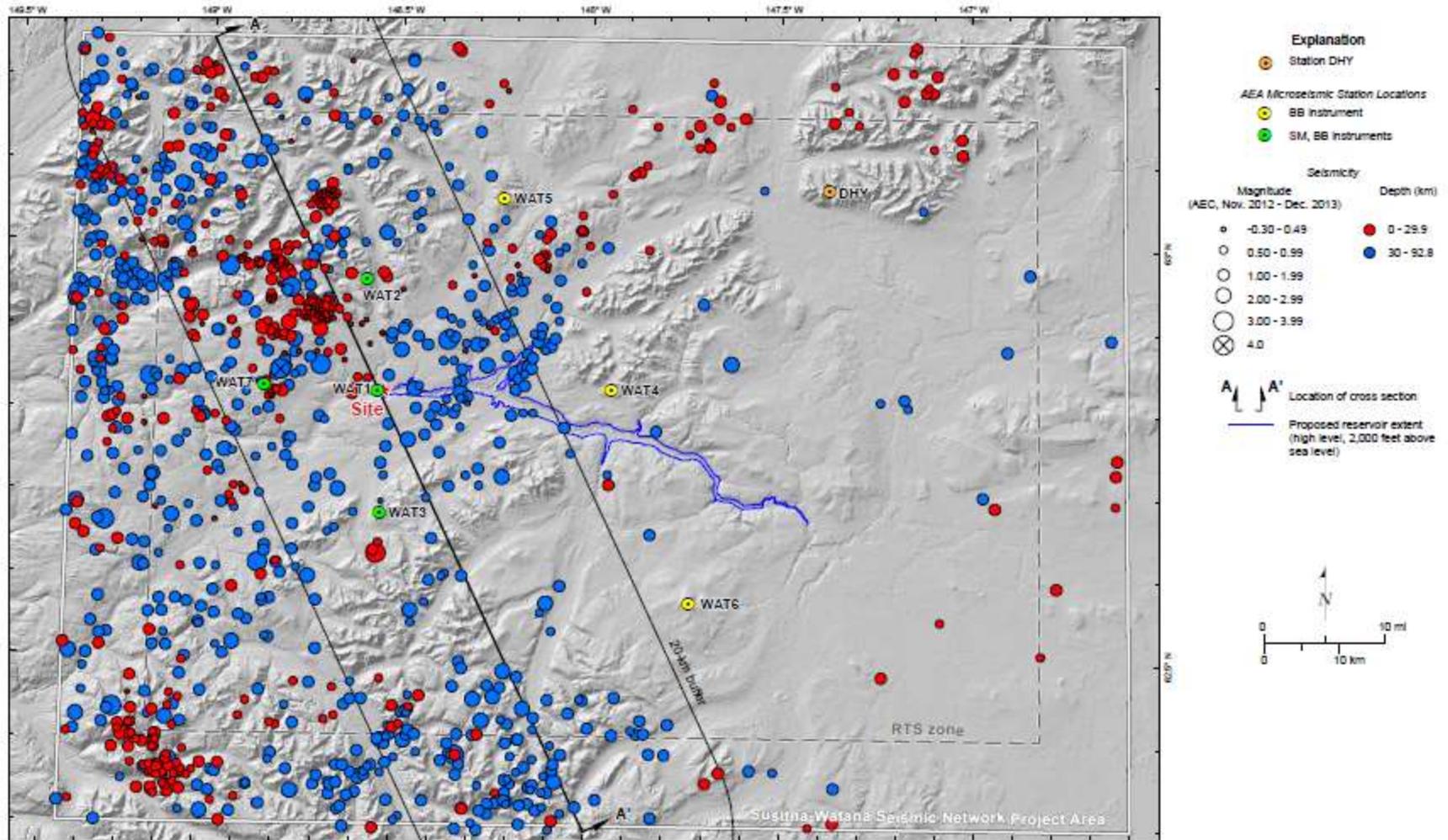
- Empirical data suggest most RTS events will have relatively small magnitudes and would most likely occur within 10 years of initial reservoir filling; may be influenced by magnitude and rate of reservoir filling
- From observations to date, the maximum RTS magnitudes may be on the order of 6.3 to 6.5

Study 16.6 Summary of Results since ISR

(Interim Crustal Seismic Source Evaluation , 2013 Seismicity Report)

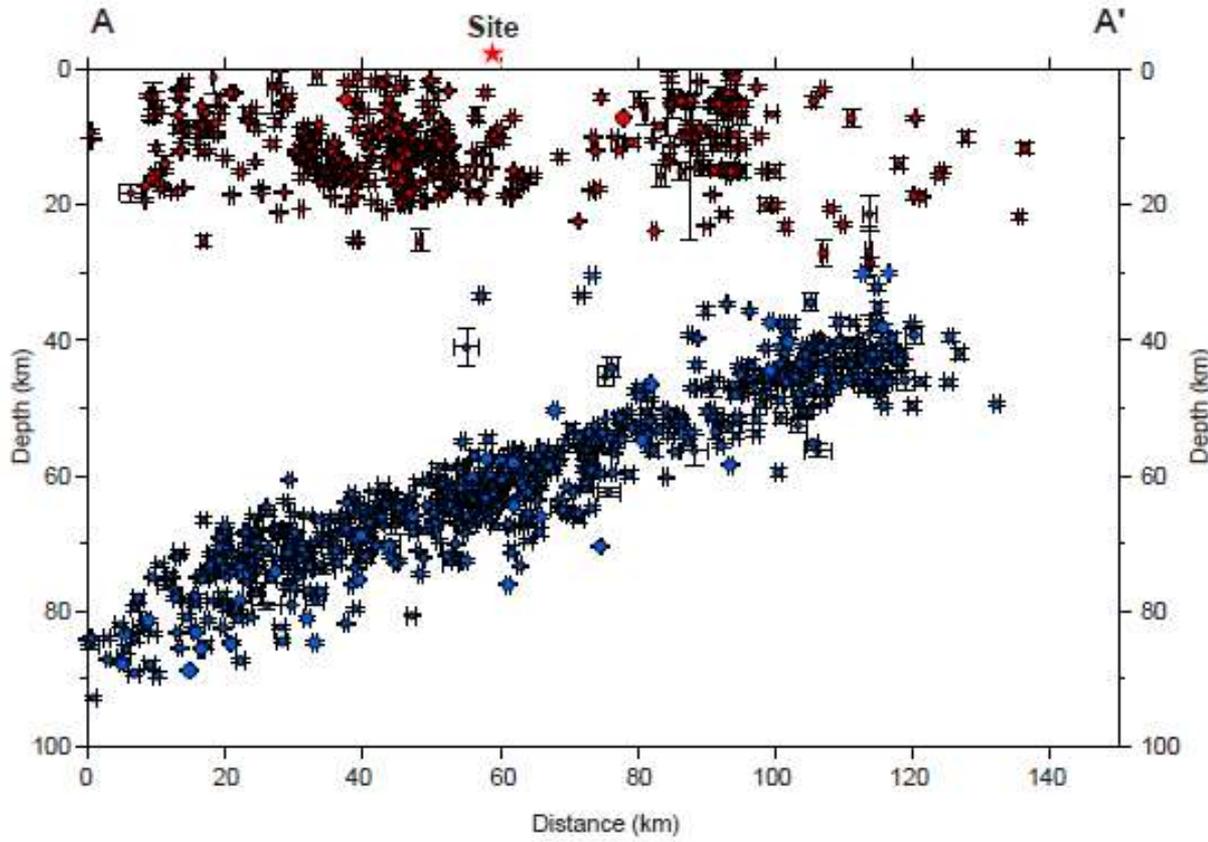
- Quaternary faults or folds mapped by State of Alaska are consistent with those recognized by this study.
- No mapped Quaternary faults within Talkeetna Block near dam site.
- Evidence of the absence of late Quaternary tectonic geomorphology, within the last 12k to 15k years, suggestive of high slip rates, based on field investigation and assessment.
- Increase in recorded events has led to a better picture of shallow crustal seismicity and intraslab seismicity associated with the subducting Pacific Plate below the proposed dam site; new slab model - segmented down-going slab.
- Focal mechanisms for earthquakes in the M4 range in the area around the proposed dam site indicate:
 - for shallow crustal events, the crust is undergoing N-NW S-SE oriented compression, consistent with the convergence between the Pacific-North America plate margin.
 - for intraslab events, indicate strike-parallel horizontal compression within the down-going Pacific Plate (in an E-W direction) .

Study 16.6 Summary of Results since ISR (Seismic Network 2013 Annual Seismicity Report)

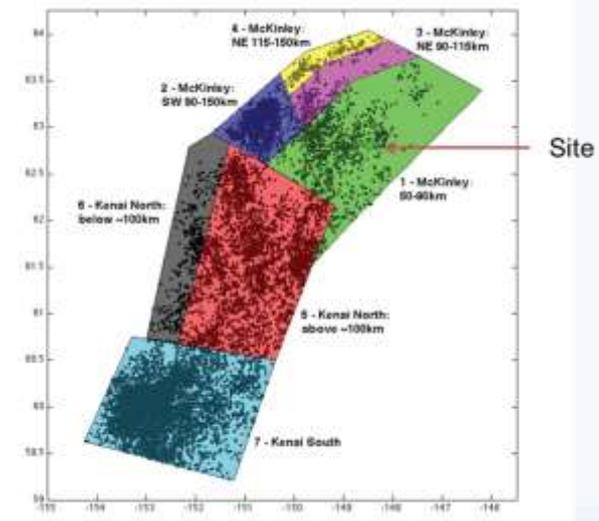


Study 16.6 Summary of Results since ISR (Seismic Network 2013 Annual Seismicity Report)

November 16, 2012 - December 31, 2013



- Explanation**
- Crustal events (depths <30 km)
 - Intraslab events (depths ≥30 km)



AEA Proposed Modifications to Study 16.6 in ISR (ISR Study 16.6, Part C – Section 7.1.2)

- No modifications to the Study Plan are needed to complete the study and meet Study Plan objectives

Current Status and Steps to Complete Study 16.6

- Current Status:
 - Completed the 2014 Field Investigation program – Field Assessment of Crustal Seismic Sources, Potential for Fault Displacement
 - Samples of Geologic Materials Collected for Age Dating Purposes
 - Seismic Event Monitoring Continues
- Steps to Complete Study:
 - Update understanding of geologic conditions and seismo-tectonic setting for the dam site area.
 - Identify and characterize the seismic sources, including detailed geologic studies and lineament analyses.
 - Identify and characterize any faults near or beneath the dam.
 - Complete deterministic and probabilistic seismic hazard assessments.
 - Assess risk to Project structures and operations associated with seismic loading conditions.
 - Propose appropriate seismic design criteria.

Steps to Complete Study 16.6 (ISR Study 16.6, Part C – Section 7.1)

To complete the study, AEA will continue to implement the methods in the Study Plan. These activities include the following:

- Update the understanding of geologic conditions and seismo-tectonic setting for the dam site area
- Identify and characterize the seismic sources, including detailed geologic studies and lineament analyses
- Identify whether a fault may be encountered beneath or adjacent to the dam and assess the activity of the feature and, if active, the likelihood for potential fault displacement or ground offset
- Perform a deterministic and probabilistic seismic hazard assessment in order to define earthquake ground motions for structural analyses.
- Assess risks to Project structures and operation associated with seismic loading conditions
- Propose appropriate seismic design criteria

Licensing Participants Proposed Modifications to Study 16.6?

- Agencies
- CIRWG members and Ahtna
- Public