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

**Groundwater Study
Study Plan Section 7.5**

**Initial Study Report
Part C: Executive Summary and Section 7**

Prepared for

Alaska Energy Authority



SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

Geo-Watershed Scientific

June 2014

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EXECUTIVE SUMMARY

Groundwater Study 7.5	
Purpose	The Groundwater Study is one part of a set of interdisciplinary resource studies that are designed to evaluate the overall effects of the Susitna-Watana Hydroelectric Project (Project) operations. The Groundwater Study is specifically linked with both the Riparian Instream Flow Study and the Fish and Aquatics Instream Flow Study since the ecological functionality of riparian and aquatic habitats can be directly influenced by groundwater/surface water (GW/SW) interactions. The Groundwater Study uses existing information and data, as well as newly collected data to provide an overall understanding of GW/SW interactions in support of the Aquatic Instream Flow Study, Riparian Instream Flow Study, Water Quality Study, Ice Processes Study and Geomorphology Study.
Status	The Groundwater Study was initiated in 2013. The 2013 data collection program was successfully completed, meeting all objectives. Automated data collection stations for measuring groundwater, surface water, soil, meteorological, streambed temperature profiles and water quality conditions were installed in five Focus Areas. Sixty six (66) groundwater wells were installed in various Focus Areas as planned. Data collection locations and elevations were established to Project survey standards. The groundwater, surface water, water quality, meteorological, and ice processes data collection stations are continuously collecting data with a majority of the stations on a telemetry network providing study team's regular, near-real-time, data access.
Study Components	The Groundwater Study has nine study elements. These include: (1) existing data synthesis, (2) geohydrologic process-domains and terrain; (3) Watana Dam/Reservoir, (4) upwelling/springs broad-scale mapping, (5) riparian vegetation dependency on GW/SW interactions, (6) fish habitat GW/SW interactions, (7) water quality in selected habitats, (8) winter GW/SW interactions, and (9) shallow groundwater users. The majority of the Groundwater Study efforts are supporting aquatic and riparian habitat evaluations. Aquatic evaluations include observations and measurements of basic surface-water and groundwater hydrology and water quality processes. Riparian evaluations include measurements, modeling, and analysis of groundwater and surface-water interactions and moisture flux and soil pore-water availability in the unsaturated soils above shallow water tables.
2013 Variances	AEA implemented the methods as described in the Study Plan with the exception of the variances listed below. • The schedule for completion of the annotated bibliography and literature review was adjusted to be complete in 2014. (See Section

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	4.1.1) • The schedule for completion of the mapping of geohydrologic units and associated analysis will be completed in 2014. (See Section 4.2.1) • The schedule for completion of the groundwater flow models, including model input and calibration data sets, files and model documentation was rescheduled into 2015. (See Section 4.5.1) • The schedule for completion of the groundwater flow models, including model input and calibration data sets, files and model documentation was rescheduled into 2015. (See Section 4.6.1) • The schedule for completion of the groundwater flow models, including model input and calibration data sets, files and model documentation was rescheduled into 2015. (See Section 4.7.1) • Water quality data from other studies completed in the first study year will be used in the next year of study to describe the differences between productive and non-productive habitat types. (See Section 4.7.1)
Steps to Complete the Study	AEA expects to complete data collection in both the 2014 and 2015 study seasons, which will be reported in the USR. AEA is planning the following activities for 2014: • Completion of annotated bibliography and literature review. • Completion of geohydrologic process-domains. • Completion of surveying of select hydrologic sites in Watana Dam area. • Completion of upwelling/springs broad scale mapping, including incorporation of thermal infrared imagery, winter open leads and 80s information. • Field data collection for support of riparian study sites, including operations and data quality assurance processing of continuous data stations (hydrology, geotechnical, meteorological, sap flow), select manual hydrologic data, time lapse camera and manual photographic data sets. Modeling development and documentation of groundwater models and integration methods for linkages to 1D river flow routing models (with final analysis occurring in 2015). • Field data collection for support of aquatic study sites, including operations and data quality assurance processing of continuous data stations (hydrology, water quality, meteorological), select manual

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	hydrologic data, time lapse camera and manual photographic data sets. • Modeling development and documentation of groundwater models and integration methods for linkages to 1D river flow routing models. • Development of process relationship methods between mainstem flow and flow in select lateral habitat. • Collection of water quality data to use in conjunction with other studies to describe water quality conditions in lateral habitat and potential differences between selected productive and non-productive aquatic habitats (with final analysis completed in 2015). • Winter data collection in coordination with other studies to help define winter groundwater/surface-water interactions (with final analysis and reporting will be completed in 2015). • Collection of groundwater data from shallow groundwater user wells and other hydrologic data collection with analysis and reporting completed. AEA is planning the following activities for 2015: • Completion of Watana Dam aquatic hydrology evaluation occurring in 2015 • Winter data collection in coordination with other studies to help define winter groundwater/surface-water interactions, with final analysis and reporting completed. • Select data collection in coordination with other studies in summer 2015 to define groundwater/surface-water interactions. • Completion of the groundwater flow models, including model input and calibration datasets, files, and model documentation.
Highlighted Results and Achievements	The Groundwater Study began installation of data collection stations in spring 2013 and completed all the planned 57 station installations and 66 shallow groundwater wells by end of summer field operations. Data collection was ongoing during this period at continuously operated stations. Manual empirical measurements of groundwater and surface water were also made in support of project objectives. Data station collection efforts are ongoing during the winter season. Empirical data collected, and field observations through the spring, summer, fall and early winter periods of the hydrologic cycle, have resulted in a more complete and defensible understanding of existing groundwater conditions. Furthermore, these observations contribute to the characterization of important habitat elements. Observations from the groundwater, surface-water and meteorological stations provide all of the physical process modeling efforts

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	(aquatic IFS, riparian IFS, water quality, geomorphology, and ice processes) on-the-ground empirical verification benchmarks for calibration and verification of the physical process models. Shallow groundwater was found to be prevalent in the Middle River portion of study area. Hillslope hydrological contributions from adjacent sides of the river valley to the floodplain were observed and measured. These include; springs and seeps, upland beaver ponds, areas without winter snow due to shallow groundwater conditions, and observed open water conditions in a majority of the sloughs and creeks (open leads). Interactions between river stage and groundwater processes were observed and measured. Field observations and data collection are ongoing daily through the winter period and will continue during 2014 and 2015.

7. COMPLETING THE STUDY

7.1. Proposed Methodologies and Modifications

To complete this study, AEA will implement the methods in the Study Plan, except as described in Section 7.1.2. These activities include:

- Existing Data Synthesis (RSP Section 7.5.4.1.1)
 - Completion of annotated bibliography and literature review in coordination with Riparian IFS (Study 8.6) and IFS (Study 8.5). (See ISR Section 4.1)
- Geohydrologic Process-Domains (RSP Section 7.5.4.1.2)
 - Completion of geohydrologic process-domains in coordination with Riparian IFS (Study 8.6). (See ISR Section 4.2)
- Watana Dam/Reservoir (RSP Section 7.5.4.2)
 - This study component will be completed in 2015 to allow incorporation of the 2014 field data efforts for the Geology and Soil Characterization (Study 4.5). (See ISR Section 4.3)
 - In coordination with the Geology and Soil Characterization (Study 4.5) data collection program, field surveying of wells, boreholes and other hydrologic features will be conducted in the 2014 field season. (See ISR Section 4.3)
- Upwelling/Springs Broad-Scale Mapping (RSP Section 7.5.4.3)
 - This study component will be completed in 2014. Thermal Infrared Remote Imaging (TIR) data collected by Water Quality (Study 5.5), winter open leads mapping by Ice Processes (Study 7.6), data from the 1980s studies and other relevant information will be used to meet the objectives in the Groundwater Study Plan. (See ISR Section 4.4)
- Riparian Vegetation Dependency on Groundwater / Surface-Water Interactions (RSP Section 7.5.4.4)
 - This study component will continue to collect data to meet study objectives in 2014. This will include data collection in FA-138 (Gold Creek) on the right bank side. Data collection objectives for this Focus Area will be met in 2014. Data collection will continue in 2014 for FA-128 (Slough 8A), FA-115 (Slough 6A) and FA-104 (Whiskers Slough) at the data collection stations established in 2013. At least three groundwater wells and four continuous surface-water stations will be established in early summer 2014 in FA-173 (Stephan Lake Complex), along with at least eight manual water level measurement sites in main channel and lateral habitat water bodies. (See ISR Section 4.5)
 - Hydrologic modeling (groundwater and surface-water systems) will continue and modeling and analysis will be coordinated with other studies including integration methods for linkages to 1D river flow routing models. Preliminary conceptual models, calibrated numerical MODFLOW models (using available 2013 data) and

- associated empirical analysis on groundwater flow rates in targeted lateral habitat areas will be completed in 2014.
- Ongoing interaction with other hydrologic studies on groundwater and surface-water interactions, meteorological, geotechnical and winter hydrology will be continued during 2014.
 - Aquatic Habitat Groundwater / Surface-Water Interactions (RSP Section 7.5.4.5)
 - This study component will continue to collect data to meet study objectives in 2014. This will include data collection in FA-138 (Gold Creek), FA-128 (Slough 8A), FA-113 (Oxbow 1) and FA-104 (Whiskers Slough) at the data collection stations established in 2013. Manual water level measurement stations will be established in select lateral habitats important for IFS (Study 8.5) (RSP Section 8.5.7.5) in FA-141 (Indian River) and FA-144 (Slough 21) in early summer 2014. All measurements will be tied to Project datum. Manual water level measurements at select flows conditions will be collected. Stage plates in select side channel and slough locations will be established at these stations so other studies working in the area can easily record water level (stage) conditions. (See ISR Section 4.6)
 - Hydrologic modeling (groundwater and surface-water systems) will continue and modeling and analysis will be coordinated with other studies including integration methods for linkages to 1D river flow routing models. Preliminary conceptual models, calibrated numerical MODFLOW models (using available 2013 data) and associated empirical analysis on groundwater flow rates in targeted lateral habitat areas will be completed in 2014. Process relationship methods between mainstem flow and flow in select lateral habitats will be developed.
 - Ongoing interaction with other hydrologic studies on groundwater and surface-water interactions, meteorological, geotechnical, water quality and winter hydrology will be continued during 2014.
 - Water Quality in Selected Habitats (RSP Section 7.5.4.6)
 - This study component will continue to collect data and coordinate with other studies (Water Quality Study 5.5, IFS Study 8.5) to meet study objectives in 2014. This will include water quality data collection (temperature, relative specific conductivity, manual measurements of temperature, conductivity, and dissolved oxygen) in FA-138 (Gold Creek), FA-128 (Slough 8A), FA-113 (Oxbow 1) and FA-104 (Whiskers Slough) at the data collection stations established in 2013. Manual water quality measurement stations will be collected in select lateral habitats important for IFS (Study 8.5) in FA-141 (Indian River) and FA-144 (Slough 21) at hydrology stations established in early summer 2014. (See ISR Section 4.7)
 - Water quality data collected in 2013 will be reviewed and plans for 2014 water quality measurements will be reviewed with IFS (Study 8.5) and Water Quality (Study 5.5) in early summer 2014.
 - Winter Groundwater / Surface-Water Interactions (RSP Section 7.5.4.7)
 - This study component will continue to collect data and coordinate with other studies (Water Quality Study 5.5, IFS Study 8.5, Ice Processes Study 7.6, Riparian IFS Study

- 8.6, and Fish Distribution and Abundance Study 9.6) to meet study objectives in 2014. This will include winter observations (snow, ice cover, fall freeze-up processes) in FA-138 (Gold Creek), FA-128 (Slough 8A), FA-113 (Oxbow 1) and FA-104 (Whiskers Slough). Observations will also include lateral habitats important for IFS (Study 8.5) in FA-141 (Indian River) and FA-144 (Slough 21). (See ISR Section 4.8)
- Winter data collection observations will be reviewed with Ice Processes (Study 7.6), IFS (Study 8.5), Fish (Study 9.6), and Riparian IFS (Study 8.6) to optimize data collection efforts for winter 2014/15. Data from this time period will be used for numerical model validation and supporting empirical analysis of winter hydrology in lateral habitat areas.
 - Shallow Groundwater Users (RSP Section 7.5.4.8)
 - This study component will continue to collect data at wells established in 2013 and will also use groundwater and surface water information collected in support of Riparian IFS (Study 8.6) and IFS (Study 8.5) to help meet project objectives. Private homeowner wells established in 2013 will continue to be measured in 2014. Analysis and objectives for this study component will be completed in 2014. No additional wells will be installed for this study component in 2014. (See ISR Section 4.9)

7.1.1. Decision Points from Study Plan

There were no decision points in the FERC-approved Study Plan to be evaluated for this study following the completion of 2013 work.

7.1.2. Modifications to Study Plan

AEA implemented the methods as described in the Study Plan with the exception of the modifications listed below.

- The schedule for completion of the annotated bibliography and literature review was adjusted to be completed in 2014. This will allow additional information to be incorporated from the 1980s references located that the ARLIS library is still processing. This change in schedule will not impact the objectives of the study. AEA is scheduled to complete the annotated bibliography and literature review in 2014. (See discussion in ISR Section 4.1)
- The schedule for completion of the mapping of geohydrologic units and associated analysis was adjusted to be completed in 2014. This will allow incorporation of supporting information from other studies to be used to meet the study objectives. This change in schedule will not impact the objectives of the study. AEA is scheduled to complete the mapping of geohydrologic units and associated analysis in 2014. (See discussion in ISR Section 4.2)
- The schedule for completion of the groundwater flow models, including model input and calibration datasets, files, and model documentation was rescheduled into 2015 to provide better integration with other hydrologic modeling efforts. This change in schedule will not impact the objectives of the study. AEA is scheduled to complete the first phase of groundwater flow models and associated analysis in 2014. (See discussion in ISR Sections 4.5, 4.6, and 4.7)

7.2. Schedule

In general, the schedule for completing the FERC-approved Study Plan is dependent upon several factors, including Project funding levels authorized by the Alaska State Legislature, availability of required data inputs from one individual study to another, unexpected weather delays, the short duration of the summer field season in Alaska, and other events outside the reasonable control of AEA. For these reasons, the Study Plan implementation schedule is subject to change, although at this time AEA expects to complete the FERC-approved Study Plan through the filing of the Updated Study Report by February 1, 2016, in accordance with the ILP schedule issued by FERC on January 28, 2014.

With regard to this specific study, AEA expects to complete data collection in both the 2014 and 2015 study seasons, which will be reported in the USR.

AEA is planning the following activities for 2014.

- Completion of the annotated bibliography and literature review.
- Completion of the mapping of geohydrologic units and associated analysis.
- Data collection networks will be maintained in FA-138 (Gold Creek), FA-128 (Slough 8A), FA-115 (Slough 6A), FA-113 (Oxbow 1), FA-104 (Whiskers Slough) in 2014. This will include measurement of water levels and water quality to verify data collected from continuous data-collection stations (see Tables 4.5-1 through Table 4.6). Parameters being measured include groundwater and surface-water levels and temperature, specific conductivity, streambed temperature profiles, and photographic images. Field efforts will include repairs of any damaged sensors from spring breakup, flooding, or other sources of sensor damage or malfunction.
- Manual water level measurement stations will be established in FA-141 (Indian River) and FA-144 (Slough 21) and FA-173 (Stephan Lake Complex). FA-173 (Stephan Lake Complex) will also have at least three groundwater wells installed and self-logging pressure transducers installed in at least three wells and four surface-water measurement locations.
- The data collection stations in the Focus Areas (see Tables 4.5-1 through Table 4.6) will be maintained through the winter of 2014/15 and summer of 2015 to support the analysis objectives of the Groundwater Study and also modeling and analysis objectives of the IFS (Study 8.5), Riparian IFS (Study 8.6), Fluvial Geomorphology Modeling (Study 6.6), Ice Processes (Study 7.6), Water Quality (Study 5.5), and Fish (Study 9.6).
- Groundwater development and analysis will continue, including development of approaches and estimates of flow in lateral habitats in the Focus Areas that have study activities taking place. Approaches will be developed and validated for input between the 1D flow routing modeling and groundwater modeling and approaches to estimate groundwater conditions outside the Focus Areas. The schedule for completion of the groundwater flow models, including model input and calibration datasets, files, and model documentation was rescheduled into 2015 to provide better integration with other hydrologic modeling efforts.
- Water quality data (temperature, conductivity, dissolved oxygen) from this and other studies completed in 2013 will be used in 2014 to describe the differences between

productive and non-productive habitat types. These habitat types will be defined in the Instream Flow Study (Study 8.5).

In 2015, AEA plans to complete all remaining data collection and analysis for this study.

7.3. Conclusion

The Groundwater study accomplished the 2013 field objectives as described in the Study Plan. Furthermore, the Groundwater study team assisted and collaborated with Riparian IFS (Study 8.6), Fluvial Geomorphology Modeling (Study 6.6), Ice Processes (Study 7.6), Water Quality (Study 5.5), Fish (Study 9.6) and IFS (Study 8.5) teams in accomplishing targeted integrated efforts. The Groundwater team installed hydrologic monitoring stations in FA-138 (Gold Creek), FA-128 (Slough 8A), FA-115 (Slough 6A), FA-113 (Oxbow 1), FA-104 (Whiskers Slough) in 2013 (see Tables 4.5-1 through Table 4.6). The data collection stations include a comprehensive set of empirical data collection of groundwater, surface-water, meteorological, geotechnical and water quality parameters. This empirical data and information is being used for the Groundwater Study objectives, as well as support for hydrologic model development, calibration and validation for open-water and ice-cover flow routing models, water-quality models, geomorphology models, and associated analysis and interpretation. Additionally, water quality transects were laid out to support the water quality studies by Water Quality (Study 5.5) and IFS (Study 8.5) in FA-141 (Indian River) and FA-144 (Slough 21).

Based on data collection completed in 2013, preliminary analyses, and plans for continued data collection in 2014 and 2015, AEA expects to achieve the objectives of this study.