Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Groundwater Study
(Study 7.5)

Groundwater and Surface-Water Relationships in Support of Riparian Vegetation Modeling

Technical Memorandum

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

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LIST OF ACRONYMS AND SCIENTIFIC LABELS

Abbreviation	Definition
AEA	Alaska Energy Authority
°C	Degrees centigrade
Cfs	Cubic feet per second
Cm	Centimeter
DEMs	Digital Terrain Models
FA	Focus Area
FERC	Federal Energy Regulatory Commission
Fps	Feet per second
GW	Groundwater Study
GW/SW	Groundwater/Surface Water
GWS	Geo-Watersheds Scientific
IFS	Instream Flow Study
ISR	Initial Study Report
mg/L	Milligrams per liter
MW	Megawatts
NAVD88	North American Vertical Datum of 1988
NTU	Nephelometric Turbidity Units
POC	Proof of Concept
PRM	Project River Mile
PT	Pressure Transducer
RB	Right Bank
RSP	Revised Study Plan
RPD	Riparian Process Domain
TM	Technical Memorandum
USGS	United States Geological Survey
WSE	Water Surface Elevation

1. INTRODUCTION

1.1. Project Description

The Alaska Energy Authority (AEA) is preparing a License Application that will be submitted to the Federal Energy Regulatory Commission (FERC) for the Susitna-Watana Hydroelectric Project (Project) using the Integrated Licensing Process. The Project is located on the Susitna River, an approximately 320-mile long river in the Southcentral Region of Alaska. The Project's dam site will be located at Project River Mile (PRM) 187.1. As currently envisioned, the Project would include a large dam with an approximately 24,000-acre, 42-mile long reservoir. The Project construction and operation would have an effect on the flows downstream of the dam site, the degree of which will ultimately depend on final Project design and operations.

The Project reservoir is expected to fill during the summer months (May – August), when runoff from snow melt and rainfall is greatest, to maximize power generation capability during the winter months (October – April) when energy demand is high. As a result, seasonal changes to Susitna River streamflow conditions during Project operations may include lower discharges during the summer reservoir refill period and higher discharges during the winter relative to current hydrologic conditions. In addition to these seasonal changes, the Project may be operated in a load-following mode to meet energy demands on an hourly basis. During load-following operations, the amount of water released from the reservoir would cycle daily according to energy demands such that higher volumes would be released during peak-load hours relative to off-peak hours. Seasonal and daily/hourly changes to Susitna River hydrology would influence downstream aquatic and riparian resources and processes related to groundwater conditions and groundwater surface water conditions. As a result, AEA developed and the FERC approved (FERC 2013) a detailed Groundwater Study (GW) Study Plan (contained as Section 7.5 in the December 14, 2012 Revised Study Plan [RSP]; see AEA 2012) containing nine specific tasks that were collectively designed to evaluate the potential effects of Project operations on groundwater resources.

Task 5 of the GW plan (Study 7.5) centers on defining groundwater/surface water (GW/SW) relationships associated with riparian habitats within selected Focus Areas[1]. This task is linked with the Riparian Instream Flow Study (R-IFS) (RSP 8.6)) with one of the objectives being the development of GW/SW response functions for different locations within a FA that can be used to assess upland-dominated groundwater from riverine dominated GW/SW interactions resulting from different Project operational scenarios. GW/SW analysis completed within the selected FAs will provide a better understanding of how GW/SW processes operate more broadly and will be used to draw inferences regarding Project operational effects at other locations within the

[1] Focus Areas are specific geographic areas within the Middle Segment of the Susitna River that were selected to be intensively evaluated across multiple resource disciplines (RSP 8.5.4.2.1.2) There are ten Focus Areas located in the Middle Segment of the river (see R2 Resource Consultants 2013a). The Task 5 GW investigations were concerned with seven of the FAs including FA-104 (Whiskers Slough), FA-113 (Oxbow 1), FA-115 (Slough 6A), FA-128 (Slough 8A), FA-138 (Gold Creek), FA-141 (Indian River), and FA-144 – (Slough 21), with studies concentrated in FA-104, FA-115 and FA-128.

Middle Segment of the river. Defining lateral hydraulic gradients is a key approach to achieving this objective.

This Technical Memorandum (TM) provides an overview of the types of data and information that are being collected to support the Task 5 GW/SW activities, and describes the methods and techniques that are being applied in analyzing the data leading to development of response functions for evaluating Project operational effects. The TM provides analysis objectives for FA-115 (Slough 6A) as a primary example of upland versus riverine dominated groundwater conditions. Additional examples are shown for FA-128 (Slough 8A) and to a lesser extent FA-138 (Gold Creek). The empirical data and analysis also represents an expansion of the presentation materials provided during the Riparian Proof of Concept (POC) meetings held on April 29-30, 2014. During those meetings, information concerning the locations and methods for data collection were presented, as well as preliminary analysis showing key GW/SW processes taking place in different Focus Areas. Additional data and empirical data analysis are shown, along with the definition of lateral hydraulic gradients and the proposed approach for scaling to the riparian process domains of the Middle River. An important qualifier of this TM is that although site specific data have been used, the data analysis techniques and the results presented herein may be revised as additional data are collected.

1.2. Study Background

The Susitna River is a large glacial river that exhibits large hydrologic changes at hourly, daily, and seasonal temporal scales. Susitna River discharge is typically the highest during the snowmelt period in spring and early summer (June – August) and large, short-term fluctuations in flow volumes often occur during summer in response to air temperature changes and precipitation events. Mean monthly Susitna River streamflow for June, July, and August during water years 1950 – 2010 ranged between 21,430 – 26,290 cfs (USGS Gold Creek gage #15292000) (Curran 2012). During the open-water period, Susitna River streamflow is fed primarily by surface and glacial runoff and water turbidity levels are high (> 200 nephelometric turbidity units [NTU]) due to suspended glacial silt. Susitna River discharge levels typically decline during September through November and are lowest during December through April when the channel is largely ice covered. Winter ice processes include early winter ice development and ice jams, mid-winter ice jams, and significant ice jams during spring snowmelt and breakup. Mean monthly Susitna River streamflow for December through April during water years 1950 – 2010 ranged between 1,303 – 1,893 cfs (USGS Gold Creek gage #15292000) (Curran 2012). Winter streamflow is fed primarily by groundwater and consequently discharge is stable and slowly dropping and water turbidity is low (<10 NTU).

1.3. Technical Memorandum Objectives

This Technical Memorandum (TM) is specific to Groundwater Study (Study 7.5) and Riparian IFS (Study 8.6) hydrologic analyses. It demonstrates, through presentation of preliminary field results, GW/SW interaction elements. The objectives of this TM are (1) to provide status update concerning general 2014 groundwater and surface-water data collection activities in support of Riparian IFS, (2) provide GW/SW analyses and results using FA-115 (Slough 6A) as a primary example, (3) present additional GW/SW field results from FA-138 (Gold Creek) and FA-128 (Slough 8A), (4) present select examples from PRM 112 (Slough 6A) to introduce example sites where limited data is used to show lateral hydraulic gradient characterizations outside the Focus Areas, and (5) provide an update on GW/SW modeling progress. Groundwater Study GW/SW data collection and analyses for support of Aquatic IFS (Study 8.5) and Riparian IFS (Study 8.6) are integrated and complementary. Plans for 2015 data collection are also presented.

2. STUDY AREA

As established by RSP Section 7.5.3, the overall study area related to groundwater processes includes primarily the Middle River Segment of the Susitna River that extends from PRM 102.4 to PRM 187.1 as well as portions of the Lower River Segment associated with domestic wells and riparian transect locations in the Lower River, and the lowest portion of the Upper River Segment near the proposed dam site associated with potential groundwater changes relative to reservoir construction and operations. Figure 1 shows these river segments and the general watershed boundary of the Susitna River. Figure 2 shows the location of Instream Flow Study (Study 8.5) Focus Areas and geomorphic reaches for the Middle River Segment. The Groundwater Study established data collection stations in various Focus Areas. The naming convention for the stations is shown in Figure 3 and descriptions of current data collection parameters are shown in the tables in Appendix A. The Focus Areas and Groundwater Study hydrologic stations established in 2013 and 2014 are shown in Figure 4 through Figure 20.

3. METHODS

The described study methods are directly linked to the Riparian Instream Flow Study (Study 8.6) and associated with a number of other multidisciplinary resource studies that are jointly working on the Focus Areas including the Fish and Aquatics Instream Flow Study (Study 8.5), Geomorphology studies (Studies 6.5 and 6.6), Ice Processes Study (Study 7.6), and Water Quality studies (Studies 5.5 and 5.6). The overall goal of this study component is to collect information and data to define riparian vegetation and GW/SW interactions and function at a number of Focus Area locations. Focus Area results will be used to extrapolate effects to the riparian domain scale. These process relationship analyses will allow for assessment of potential Project operation effects on GW/SW interactions and associated riparian vegetation.

The methods employed as part of the analysis are described below and include field efforts to collect water surface elevation, as well as collection of stationary and aerial imagery to allow visual assessments of ice processes affecting surface water conditions and riparian vegetation. The photos also help verify precipitation conditions, leaf-out, leaf-off and other environmental information at the remote field areas. Methods are also presented that describe the types of data analysis that were used to evaluate lateral hydraulic gradients and define various GW/SW relationships both in terms of stage.

Ultimately, various hydraulic and physical models, including surface water hydraulic (1-D and 2-D), geomorphic reach analyses, and ice processes will be integrated as needed to allow assessment of riparian processes and hydrologic controls (see Study 8.6) under both existing conditions and Project operational scenarios. The results of the GW study will be used to draw appropriate inferences on GW/SW processes at the river segment and riparian process domain scale.

As described in the Initial Study Report (ISR), empirical data are being collected at five Focus Areas (FA-104 (Whiskers Slough), FA-113 (Oxbow 1); FA-115 (Slough 6A), FA-128 (Slough 8A); and FA-138 (Gold Creek)) to define GW/SW interactions (see ISR 7.5, Figures 4.5-2, 4.5-3, 4.5-5, and 4.5-6). Additional stations were established for manual measurements in 2014 in PRM 112 (Slough 6), FA-141 (Indian River) and FA-144 (Slough 21). The data collection stations established within each Focus Area serve multiple study needs with some of the stations collecting measurements of groundwater level and water quality (temperature and conductivity), some stations collecting measurements of surface water levels, discharge, and water quality, as wells as some fixed stations collecting time lapse photographs to document hydrologic and riparian vegetation condition changes over time.

3.1. Hydrology Observations

3.1.1. Water Surface Elevations Measurements

Water surface elevations being measured at both groundwater stations and surface-water stations within each of the Focus Areas are shown in Figure 4 through Figure 20. These measurements are intended to provide data at the various stations including those associated with specific transects for analysis of GW/SW interactions over the range of hydrologic conditions from summer through fall freeze-up, winter, and spring snowmelt and breakup.

At stations with pressure transducers (PTs), manual water level measurements were made to help process the continuous data and to apply data shifts and corrections as needed due to potential movement of the PT. The PTs used for the study also record water temperature at the location of the sensor. In addition, intergravel water temperature profiles were measured via placement of thermistor strings that recorded temperatures at different depths within the substrate. Depending on the complexity of the hydrologic station, PTs are either part of the overall sensor suites measured by Campbell Scientific Inc. CR1000 or CR200X data loggers, or are self-logging pressure transducers at groundwater and surface-water stations where fewer measurements are required.

Manual water level measurement at surface-water stations are frequently made by level-loop surveying. Level-loop surveys are performed with optical survey levels. Measurement goals for level loop closures are 0.02 ft. There are three to four reference elevation benchmarks to use for summer and winter surveying at a majority of the stations. These benchmarks have had at least one measurement point surveyed by RTK survey methods to establish sea level datum at each station.

All groundwater wells were installed by drive point methods with pre-drilling to help installation when needed. The wells all have the top of galvanized casing protected by enclosures that have survey measurement control marks on them. These measurement locations are surveyed by level loop survey methods and used as a reference point to measure the depth to groundwater in the well.

In 2014, 42 staff gages were installed in various Focus Areas and other locations to provide field crews from various studies the ability to take water level readings at these locations. This same approach was successfully used in the 1980s Susitna studies. These locations are all in lateral side channels, sloughs and beaver ponds where they require less maintenance during the summer ice free hydrologic period.

Listings of all groundwater and surface-water stations used in the GW study are provided in Appendix A, Table 1 through Table 8, which are organized by Focus Area or PRM. The station information tables include both stations and sensors installed in 2013 and in new data collection sites established in August 2014. One non-Focus Area location is included at PRM 112 (Slough 6).

3.1.2. Land-based and Aerial Photographic Imagery

Visual documentation of water levels and other hydrologic features is available at the Focus Areas via a series of land-based stationary time-lapse cameras. Photographs from these cameras can be used in part to help document the weather, hydrologic and vegetation changes within a Focus Area over time, and the connectivity of hydrologic processes to riparian vegetation.

In addition, aerial surveys were completed during a number of the field efforts to photo document conditions in all the surface-water sloughs and side channels, beaver ponds and other hydrologic features in each Focus Area. These empirical photographic data sets help document ice and snow cover conditions during winter conditions, changes in channel conditions, changing beaver dam and channel changing activities, and the general characteristics of the surface-water features in each Focus Area.

3.2. Analysis Methods

The below sections describe general data collection and preliminary data analysis methods used in this TM. The analysis considered four main periods where hydrologic conditions and related GW/SW interactions may vary. These periods are defined as Fall Freeze Up, Winter (ice cover), Spring Break-Up, and Summer (ice free) and are depicted in Figure 21, which also shows the period of record daily mean flow statistics for the Susitna River at Gold Creek USGS gaging station (15292000) (USGS, 2014). Using these seasons to help describe GW/SW interactions is important as the hydrologic processes and boundary conditions change over the seasons, as does riparian vegetation, and so will Project operations.

3.2.1. Empirical Analysis Methods

As an initial step in the Focus Area analysis, water level and temperature data were plotted together in various combinations to examine relationships between groundwater conditions and adjacent surface water features. Time series plots were then used at different time scales to show response changes between GW/SW systems. The primary information used to study these interactions are water levels as relative pressure (water height) gradients are the foremost process driving interactions. Temperature data were also used as indicators of GW/SW mass interaction, since temperatures differ between groundwater and surface water. Manual discharge measurements in channels were used to measure groundwater recharge to surface water bodies (upwelling or gaining stream reaches) or discharge from surface water to groundwater (downwelling or losing stream reaches).

For the GW Study, the study design for understanding riparian processes consisted of transects with multiple wells crossing different vegetation zones and surface-water feature of interest (slough, side channel). Water elevations in the surface water features and all groundwater locations across transects were used to develop a 2-D cross section view of GW/SW interactions. The top of the unconfined groundwater surface is also called the "water table". By comparing the difference between groundwater and surface water levels across the transect, hydraulic gradients, or water table slopes can be calculated from aquifer positions to determine the horizontal and vertical flow direction, and the extent of GW upwelling or SW downwelling between surface water and adjacent aquifers. In shallow water table settings, it is common to use a combination of shallow wells and surface-water features to map out the top of the water table. Empirical data comparisons between different types of lateral aquatic habitats and hydrologic conditions were used to understand and characterize the range of GW/SW interactions taking place across Focus Areas.

3.2.2. Lateral Hydraulic Gradient Relationships

A primary objective of this TM is to show analytical approaches and examples for defining lateral hydraulic gradients. The gradients can be described as water table slope from upland (hill slopes, high terraces) down to the main channel of the Susitna River. The water table slope is defined by the top of ground water surface and intersecting surface-water features such as streams, sloughs, side channels, wetlands, spring, and beaver ponds. By surveying all measurement locations to a common vertical datum (NAVD88), these elevations can then be compared with other sources of information, such as digital terrain models (DEMs), outputs of 2-D flow routing models and aerial images.

The temporal data collection of water level information across the different hydrologic seasons is then used to define the important boundary conditions, such as upland groundwater aquifers, and surface water features across the transects to the main channel of the Susitna River.

3.2.3. Groundwater Modeling

In addition to the analysis of empirical data that are presented in this TM, 2-dimensional (2-D) cross-sectional groundwater models are being developed for each of the riparian transects in FA-128 (Slough 8A), FA-115 (Slough 6A) and FA-104 (Whiskers Slough). These models will provide a better understanding of GW/SW interactions and how they vary across different types of lateral aquatic and riparian habitats under natural flow conditions. In addition to the 2-D modeling efforts, FA-128 (Slough 8A) was selected for development of a 3-dimensional (3-D) model for use in the Study 7.5 Task 5 IFS-Riparian studies and for comparative purposes with the 2-D models. The purpose of the 3-D model is to develop an understanding of how to apply the process understanding in the 2-D GW/SW models to the Focus Area scale and make appropriate inferences at the riparian process domain scale.

For this, the USGS modeling package MODFLOW (Feinstein et al. 2012; Maddock et al. 2012; USGS 2005) was selected for use based on guidance in ASTM D6170 "Standard Guide for

Selecting a Groundwater Modeling Code” (ASTM, 2010). ASTM standard D5981 is being used to help develop calibration goals and procedures for groundwater modeling efforts (ASTM 2008).

To date, elevation surveying has been completed at each transect to provide the upper land surface boundary and location of monitoring wells and other empirical observation points. Methods for integrating input data from the 1-dimensional (1-D) HEC-RAS model (summer, ice-free) (ISR 8.5; Appendix K (R2 2014)) are under development. The 2-D hydraulic models will be used to develop synthetic stage-discharge relationships at the groundwater modeling transects for specific flow conditions simulated by the 1-D hydraulic models. During fall freeze-up, winter, and spring breakup, output from the Ice Processes Study (Study 7.6) River1D model will be used for future stage input.

3.3. Variances from Study Plan

The GW study methods were implemented as described in the Study Plan with only some variances in schedule for tasks not related to field activities (see ISR Study 7.5, Section 4.5).

4. HYDROLOGY AND LATERAL HYDRAULIC GRADIENT RESULTS

Hydrologic observations of GW/SW interactions and related data have been made in the study areas since late summer 2013 and have covered the four primary seasons for the annual hydrologic year (Figure 21). One station (ESSFA128-1) (Figure 13) was established as part of the 2012/13 winter studies conducted by Instream Flow (Study 8.5), Fish Distribution and Abundance in the Middle and Lower River (Study 9.6) and GW (Study 7.5) study teams and measured end-of-winter 2013 conditions as well as spring snowmelt and breakup in 2013. The 2013/14 winter season and summer 2014 was intensely monitored by the network of groundwater and surface water stations in the relevant Focus Areas. During the April late-winter field trip in 2014, surface-water discharge was measured to characterize groundwater recharge/discharge (upwelling/downwelling) in select lateral habitats in FA-138 (Gold Creek) (Slough 11); FA-128 (Slough 8A) (Slough 8A); and FA-104 (Whiskers Slough) (Whiskers Creek, Slough 3A, Whiskers Slough).

An early snowmelt and breakup period was measured in late April and early May 2014. This was followed by a period of lower water level conditions in late May and early June followed by typical summer precipitation stage events in June through August. Additional surface water level, discharge and water-quality measurements were collected in September 2014 to help characterize the end of the summer 2014 hydrologic period.

4.1. FA-115 (Slough 6A)

The hydrology data collected in FA-115 (Slough 6A) in 2013 and 2014 covered a broad range of hydrologic conditions. Figure 15 shows the general location of FA-115 (Slough 6A) and the location of the primary and secondary riparian transects. The cross-section for the primary transect is shown in Figure 22. The location of wells and surface-water measurement stations are shown along with relevant surface-water features such as sloughs, beaver ponds and a side channel of the Susitna River. Groundwater and surface-water levels continuously measured from 2013 through 2014 are shown in Figure 23. The well located furthest from the secondary channel is at station ESGFA115-2. This well is located just below the slope break in an area where groundwater springs are common. A small upland stream, draining the area wetland, is also being measured. The 2013 data shows very little water level variation along this hydrologic boundary. The lower beaver pond on Slough 6A is measured by ESGFA115-5, along with an adjacent well located on the river side of the beaver pond. Water levels in the beaver pond vary more due to summer precipitation, winter ice development, and spring snowmelt, than hydrologic interaction with the Susitna River. In comparison, the well adjacent to the beaver pond at ESGFA115-5 shows some variation due to river stage changes. The well located adjacent to the Susitna River side channel at ESGFA115-7 is shown for comparison. This well shows the rapid response of groundwater levels to surface water stage changes.

4.2. FA-138 (Gold Creek)

FA-138 (Gold Creek) has a minor riparian transect located on the right bank (RB) of the Susitna River main channel. The riparian transect covers an upland wetland area and has two surface-water measuring stations (ESGFA138-6, ESGFA138-7, Figure 8, Figure 9). At the ESGFA138-7 station, field crews survey surface-water stage levels during station visits. This transect is just downstream from the Susitna River at Gold Creek USGS gage and a simple offset is calculated to adjust the stage values measured at the USGS gage to the transect location. The cross-section of the riparian transect and associated hydrology features are shown in Figure 24. The groundwater surface (water table) is at land surface for most of the riparian transect. The annual surface water levels for the abandoned slough at ESGFA138-6 and the abandoned upland slough at ESGFA138-7 are shown in Figure 25. The adjusted stage levels for the Susitna River at the ESGFA138-7 location are also shown to help demonstrate the elevation differences between the upland water features and the stage in the river. The data collected over 2013 and 2014 do not show a riverine dominance in the shallow wetland or other surface-water features. Groundwater recharge from uplands and summer precipitation and spring snowmelt are the controlling hydrologic conditions maintaining the water levels in the upland wetlands.

4.3. FA-128 (Slough 8A)

There are two riparian transects in FA-128 (Slough 8A) (Figure 11, Figure 13, and Figure 14). The upper riparian transect was chosen to illustrate an example of a floodplain that is more riverine dominated throughout the transect (Figure 26). The upper riparian transect extends from Upper Side Channel 8A across the island to Slough 8A. During the period water levels are shown on the transect (4/20-23/2014), the water table gradient is from the side channel to Slough 8A. Water levels for the Upper Side Channel 8A and Slough 8A are shown in Figure 27. The groundwater system responds rapidly to stage changes in the mainstem, with some of the highest water table conditions occurring during winter (ice affected) period and spring snowmelt and breakup. The continuous water level data shows different periods where groundwater levels reverse. The data indicates the water table conditions are highly dependent on the surface-water boundary conditions in the side channel and slough.

5. DISCUSSION

The data collection efforts in 2013 and 2014 characterize the upland dominated groundwater to riverine dominated groundwater conditions. FA-115 (Slough 6A) is a good representation of the difference between upland groundwater controlled conditions on the high slopes and terraces down to riverine dominated groundwater conditions near the Susitna River (Figure 22 and Figure 23). The upper riparian transect in FA-128 (Slough 8A) offers a contrast and shows riverine dominated conditions (Figure 26 and Figure 27). The data from these and other transects will be used to define the range of shallow groundwater conditions and the limits of riverine processes.

5.1.1. Hydrology and Lateral Gradients

The hydrology studied in the Focus Areas was viewed at the landscape scale by applying a hydrologic terrain approach as described by Winter, 1998. Examples of hydrologic terrains that apply to the Focus Area settings are shown in Figure 28 and Figure 29. The mountainous terrain example is analogous to the Middle River section of the Susitna River passing through the Talkeetna Mountains. Regional groundwater base flow recharges the river and adjacent floodplain and hill slopes. Where groundwater intersects the land surface, seeps, springs, wetlands and vegetation dependent on shallow groundwater conditions are observed. The riverine terrain is seen in Focus Areas settings such as FA-128 (Slough 8A).

A combination of these hydrologic terrain settings can be seen in the FA-138 (Gold Creek) Focus Area. Figure 30 shows a valley transect that crosses the FA-138 (Gold Creek) riparian transect. The hydrologic groundwater and surface water processes will be similar to that shown in Figure 28 and Figure 29. Groundwater recharge occurs throughout the recharge area, with large recharge areas occurring above the floodplain. This is further illustrated at the floodplain scale in Figure 31 and Figure 32. Field observations of seepage faces, shallow groundwater conditions, and seasonal variation though the different hydrologic periods (Figure 21) help demonstrate how these processes interact at the Focus Area scale.

The riparian transect in FA-138 (Gold Creek) shows a good example of a floodplain wetland setting adjacent to the river that is controlled by groundwater and local precipitation and snowmelt (Figure 24, Figure 25). The data collected over 2013 and 2014 demonstrate that water level conditions in the wetland and associated water bodies are not affected by Susitna River stage fluctuations. Aerial images of this cross section are shown in Figure 33. The abandoned beaver ponds and sloughs in these sections are maintained by the regional groundwater discharge to the area. This has been further observed by open water conditions in winter months in the water bodies associated with warm groundwater discharge decreasing surface water freezing during winter months.

Approaches were developed in 2014 to develop and transfer the understanding gained at the riparian transect scale to the river segment and riparian process domain scales. An additional transect was established in FA-115 (Slough 6A) (Figure 34) to help show the application of the approach of lateral gradients within the Focus Area. Two additional examples are also shown for Slough 6 at PRM 112 in Figure 17, Figure 35, and Figure 36. Manual water level measurement stations (staff gages) at the PRM 112 cross-sections were established in 2014 to help develop and demonstrate the methods for transferring the understanding of lateral hydraulic gradients outside of the Focus Area transects.

An example of the hydrologic features of the lateral gradients is shown in Figure 37 for FA-115 (Slough 6A). The upper portion of the figure shows measured conditions and surface hydrology features that can be seen on the ground and in aerial photographs and imagery. The lower portion of the figure shows areas of groundwater control and surface-water (riverine) control. A "hinge-point" is defined as the location where Susitna River riverine flow and stage changes do not significantly impact adjacent groundwater conditions and lateral water bodies. In this Focus Area example, Slough 6A, a large beaver dam is located. The hydrologic boundary conditions at the end of the riparian transect, where regional groundwater seeps and springs occur, show very little annual fluctuation in water levels. The Susitna River is the boundary condition at the opposite end of the hydraulic gradient. It varies with the processes taking place over the hydrologic season's characteristics for the area.

5.1.2. Scaling Lateral Hydraulic Gradients to Riparian Process Domains

The process understanding gained in the Focus Areas, and other analyses and modeling, will be used for scaling the lateral hydraulic gradients to the river segment and riparian process domain scale. A spatial analysis (GIS) approach will be developed using the Focus Area 2013/2014 GW/SW results. The analysis will integrate GW/SW field measurements, spatial GIS products and 1-D/2-D flow routing models to define the extent of riverine influences on the groundwater system and associated impact on riparian vegetation. The spatial approach will then be used to scale up the Focus Area hydraulic gradient analysis to the river segment and riparian domain scales.

6. PLANS FOR 2015

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. The GW studies associated with Task 5 will continue in 2015 with a focus on: a) collection of hydrologic data (surface and groundwater) within FA-104 (Whiskers Slough), FA-113 (Oxbow 1), FA-115 (Slough 6A), FA-128 (Slough 8A), FA-138 (Gold Creek), FA-141 (Indian River), and FA-144 (Slough 21); b) continued meteorological and limited sap flow data collection through September 2015 for a second full season; c) data collection at lower river stations for a full summer season in 2015, with stations removed end of September 2015, c) continued analysis of empirical data and development of GW/SW and lateral hydraulic gradient relationships; d) completion of MODFLOW modeling to support data analysis; e) development of lateral gradient scaling approach and analysis; and e) development of specific groundwater related parameter inputs needed to support the R-IFS (Study 8.6) modeling and analysis, and Instream Flow (Study 8.5) Focus Area models as well as other modeling efforts (e.g., Water Quality Model (Study 5.6); Fluvial Geomorphology Model (Study 6.6); Ice Processes (Study 7.6).

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8. FIGURES

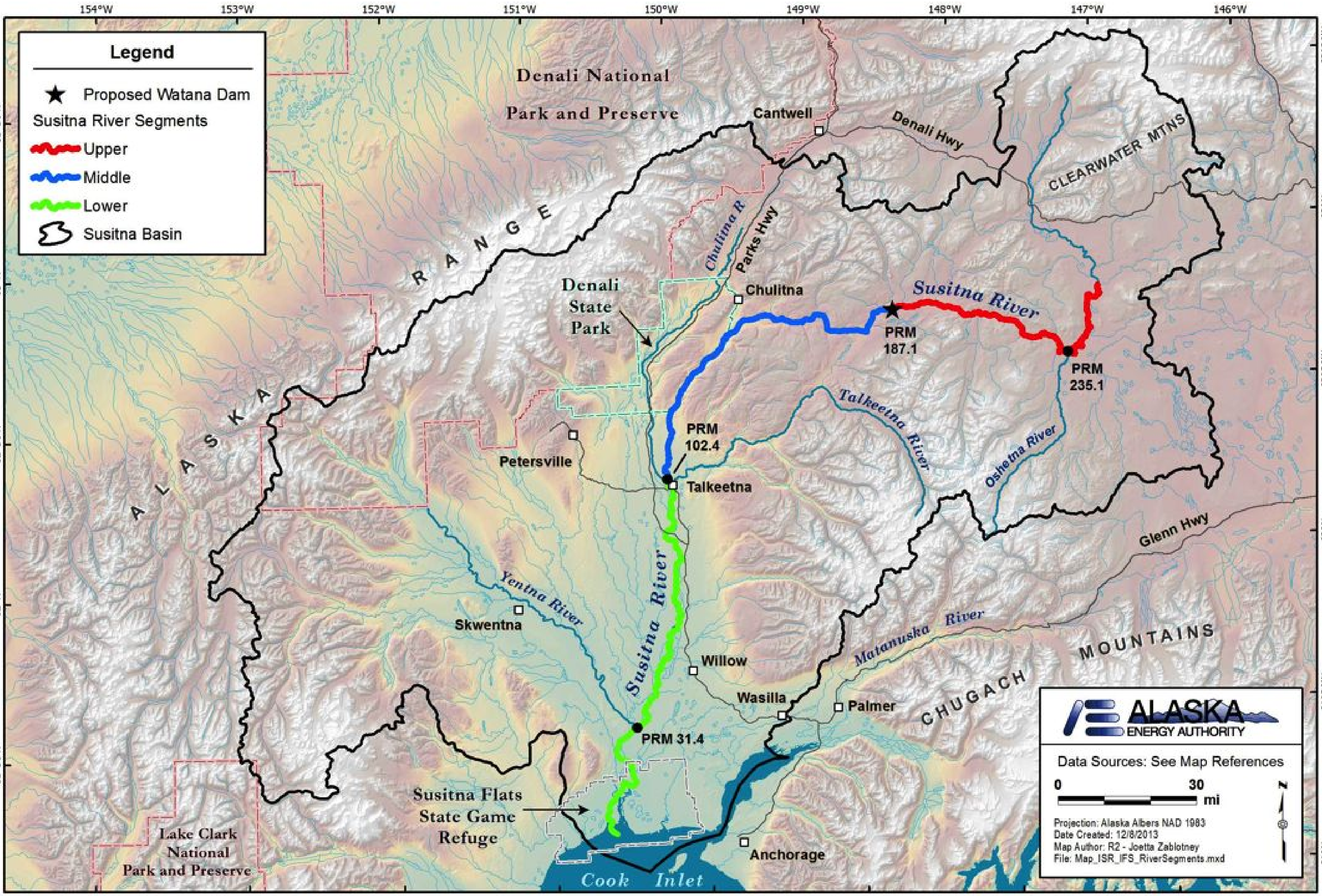


Figure 1. Susitna Watershed basin boundaries, showing the Project designation of Upper, Middle and LowerRriver segments.

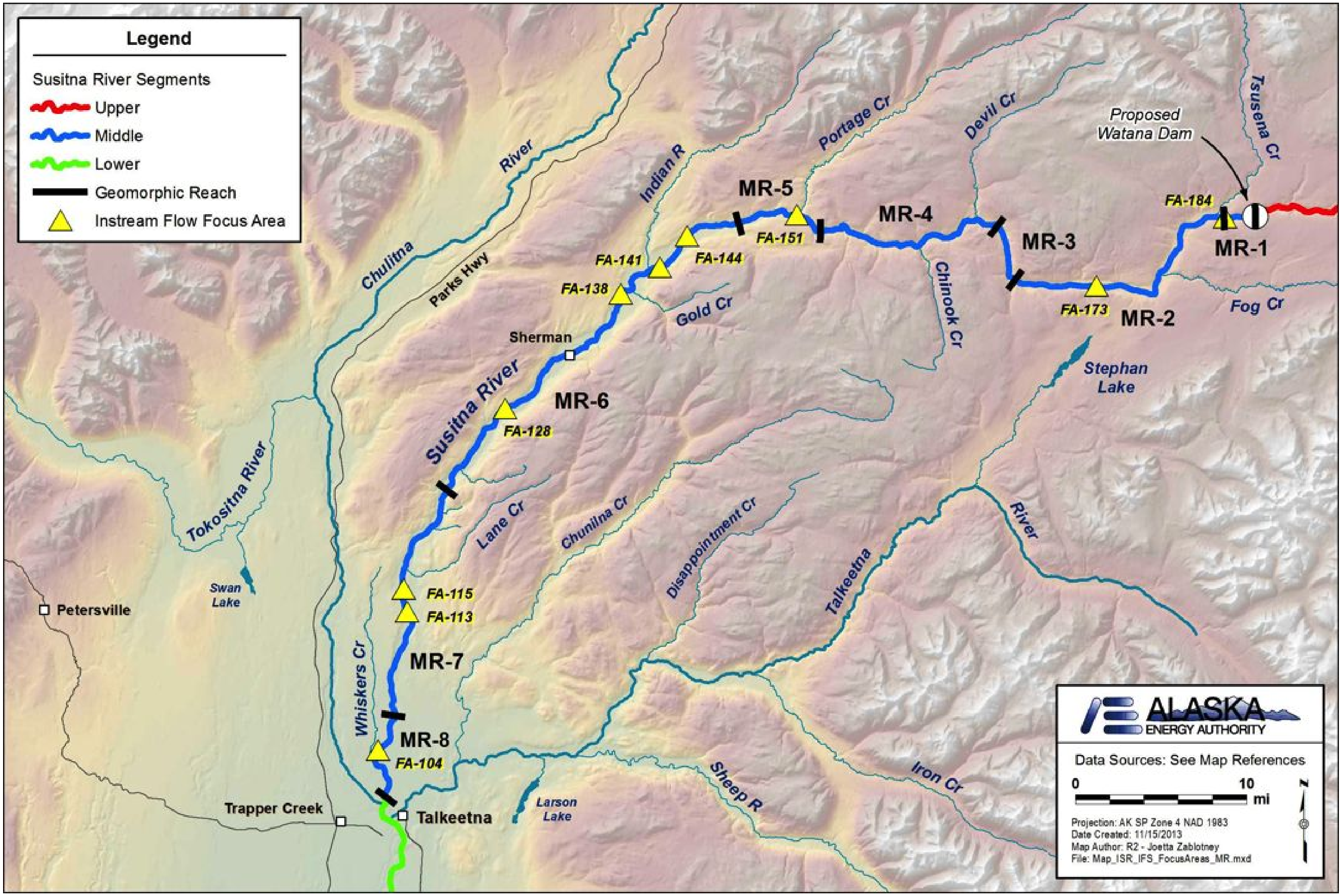


Figure 2. Susitna Watershed Middle River Segment, with geomorphic reaches and Focus Areas indicated.

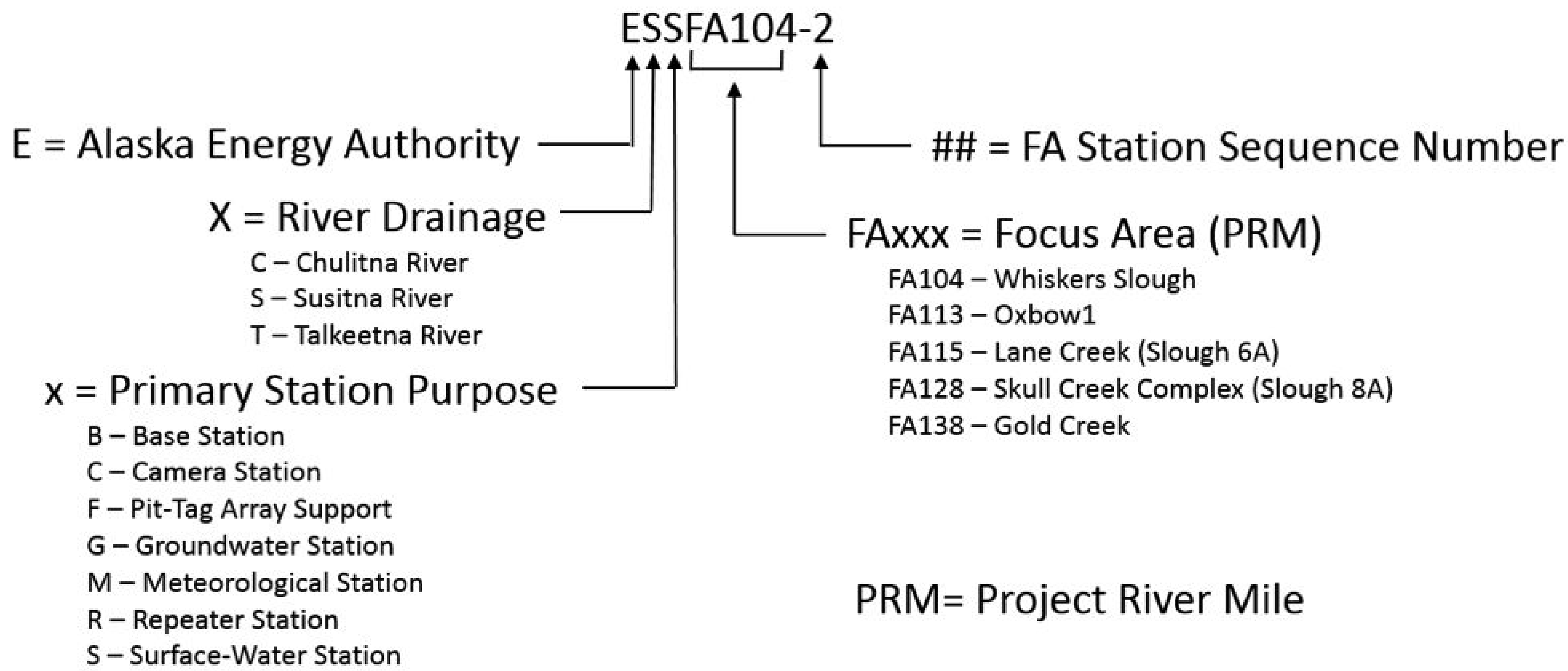


Figure 3. Data collection station short name convention used for continuously monitored stations.

Figure 4. General location of FA-144 (Slough 21) Focus Area, showing major data collection stations

Figure 5. General location of FA-141 (Indian River) Focus Area, showing major data collection stations

Figure 6. Inset A shows locations of aquatic transect stations with continuously measured parameters at FA-141 (Indian River) Focus Area.

Figure 7. Inset B shows locations of aquatic transect stations with continuously measured parameters at FA-141 (Indian River) Focus Area.

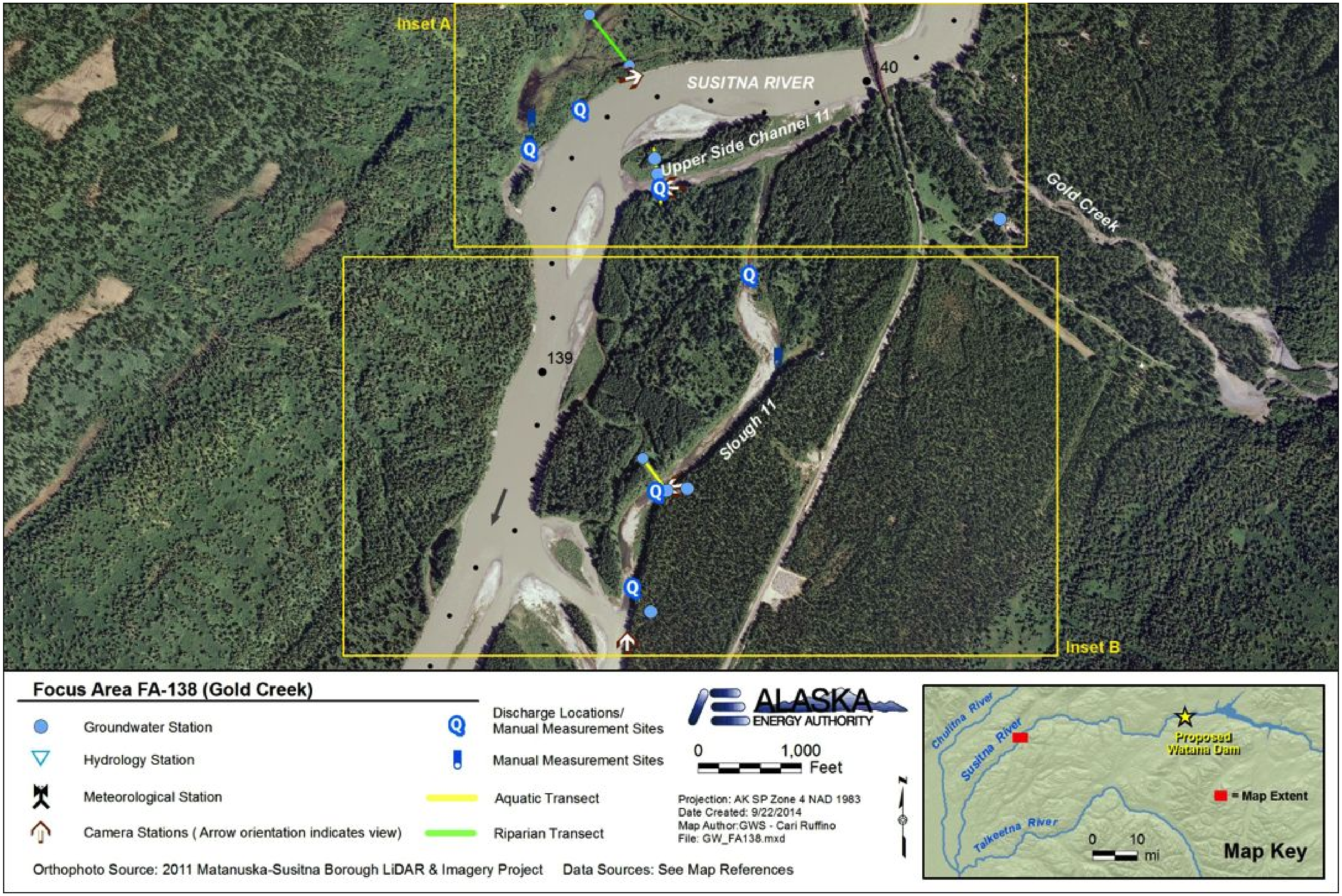


Figure 8. General location of FA-138 (Gold Creek) Focus Area, showing major data collection stations and aquatic and riparian transects.

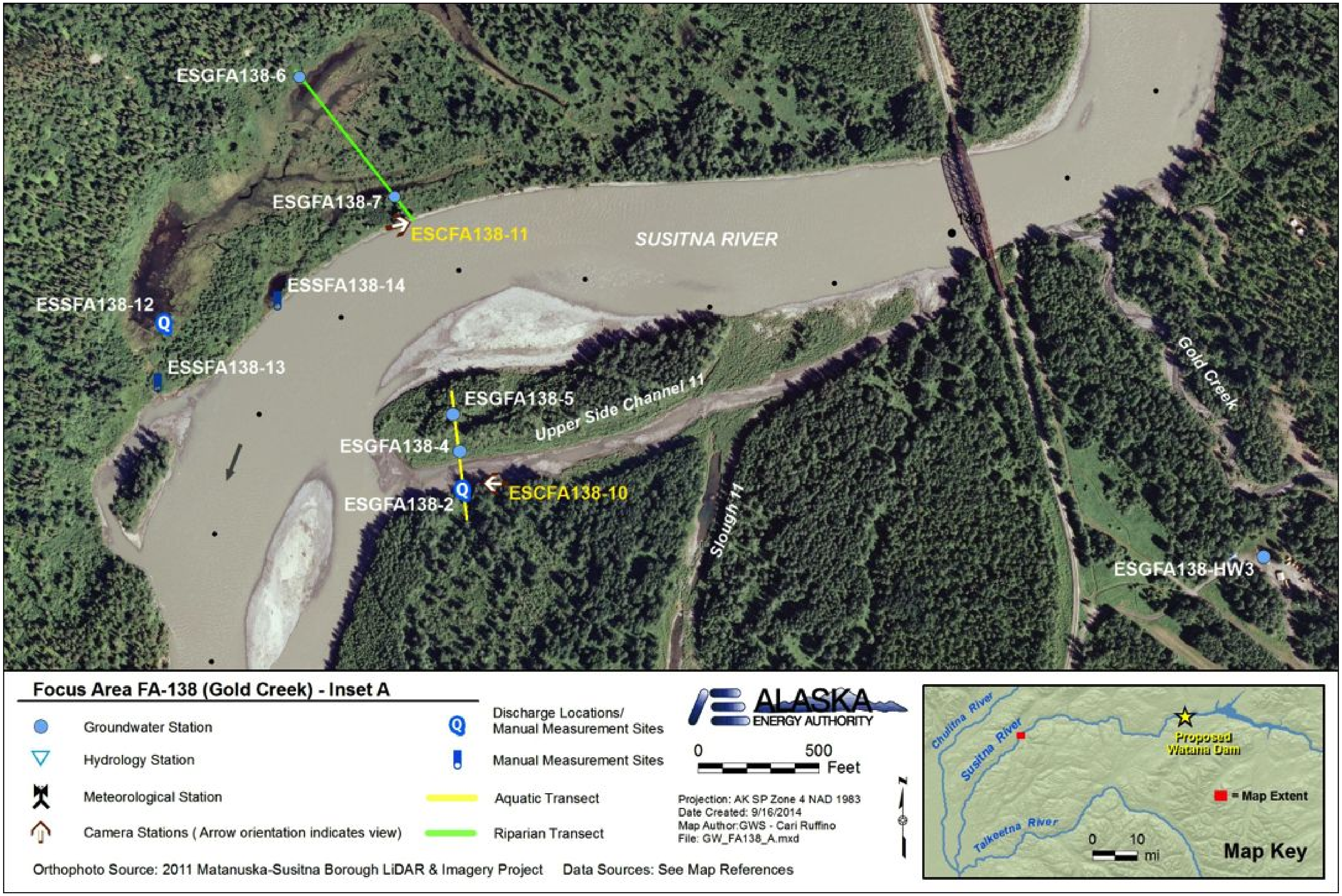


Figure 9. Inset A shows locations of aquatic transect stations with continuously measured parameters at FA-138 (Gold Creek) Focus Area.

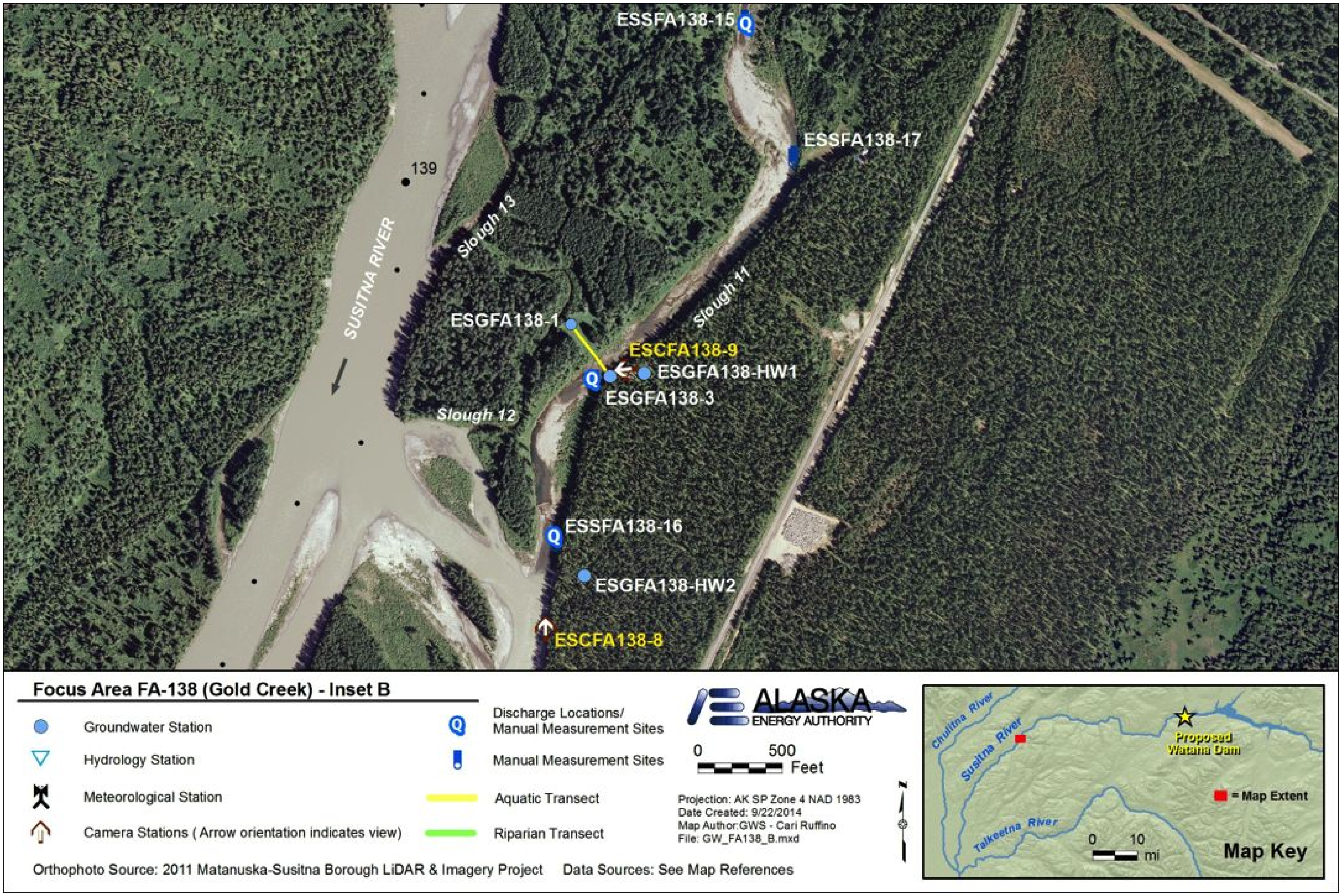


Figure 10. Inset B shows locations of aquatic transect stations with continuously measured parameters at FA-138 (Gold Creek) Focus Area.

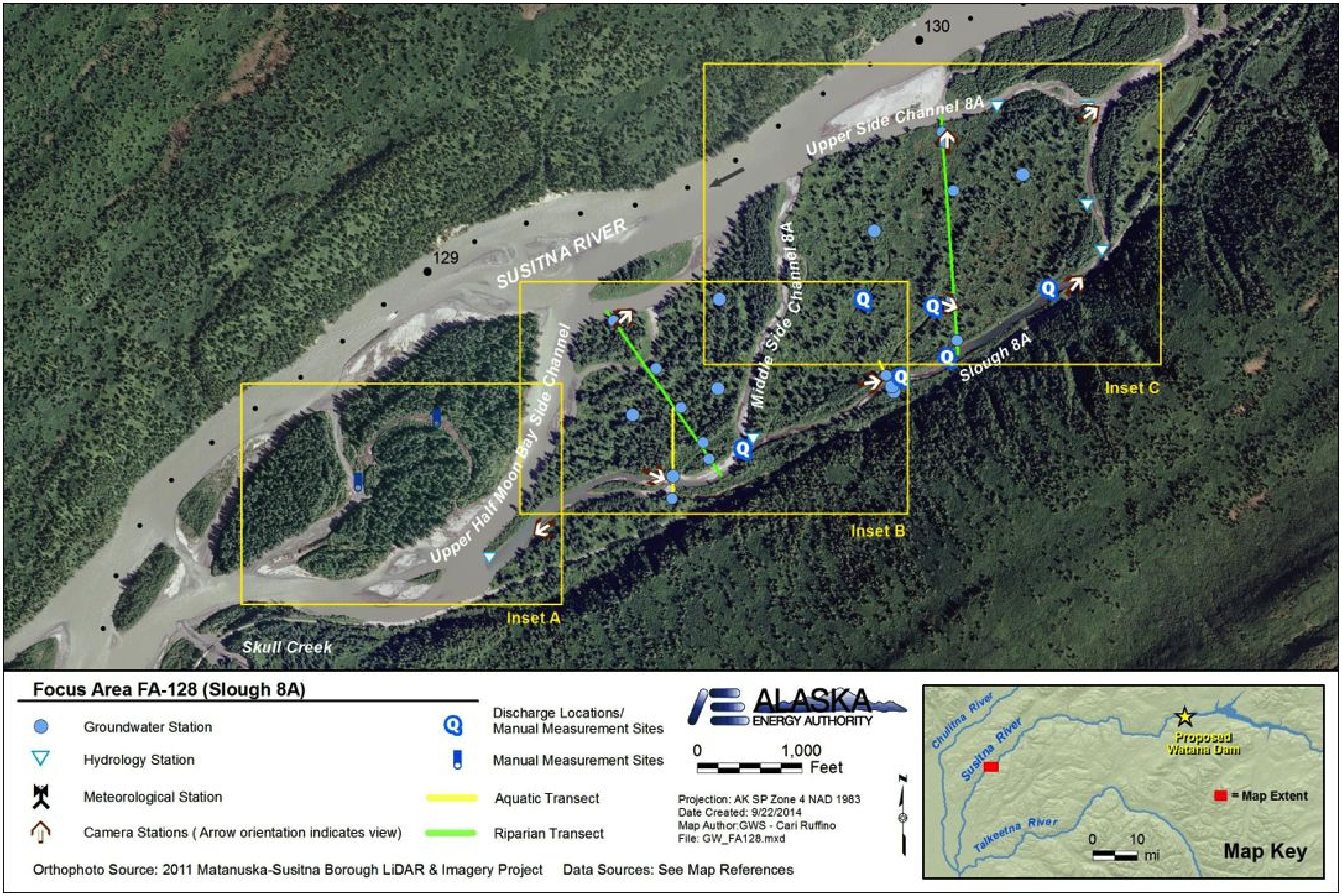


Figure 11. General location of FA-128 (Slough 8A) Focus Area, showing major data collection stations and aquatic and riparian transects.

Figure 12. Inset A shows locations of aquatic transect stations with continuously measured parameters at FA-128 (Slough 8A) Focus Area.

Figure 13. Inset B shows locations of aquatic transect stations with continuously measured parameters at FA-128 (Slough 8A) Focus Area.

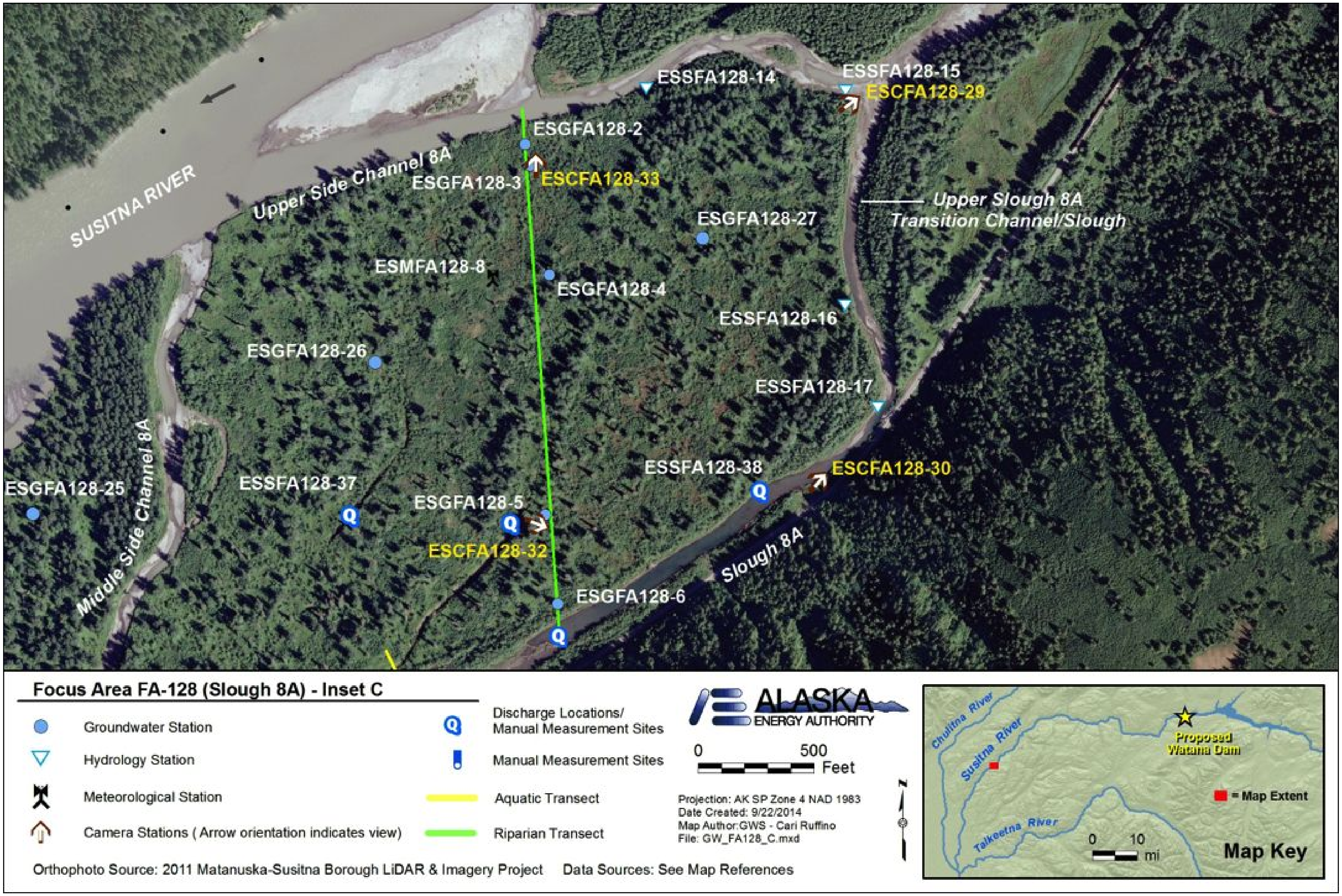


Figure 14. Inset C shows locations of aquatic transect stations with continuously measured parameters at FA-128 (Slough 8A) Focus Area.

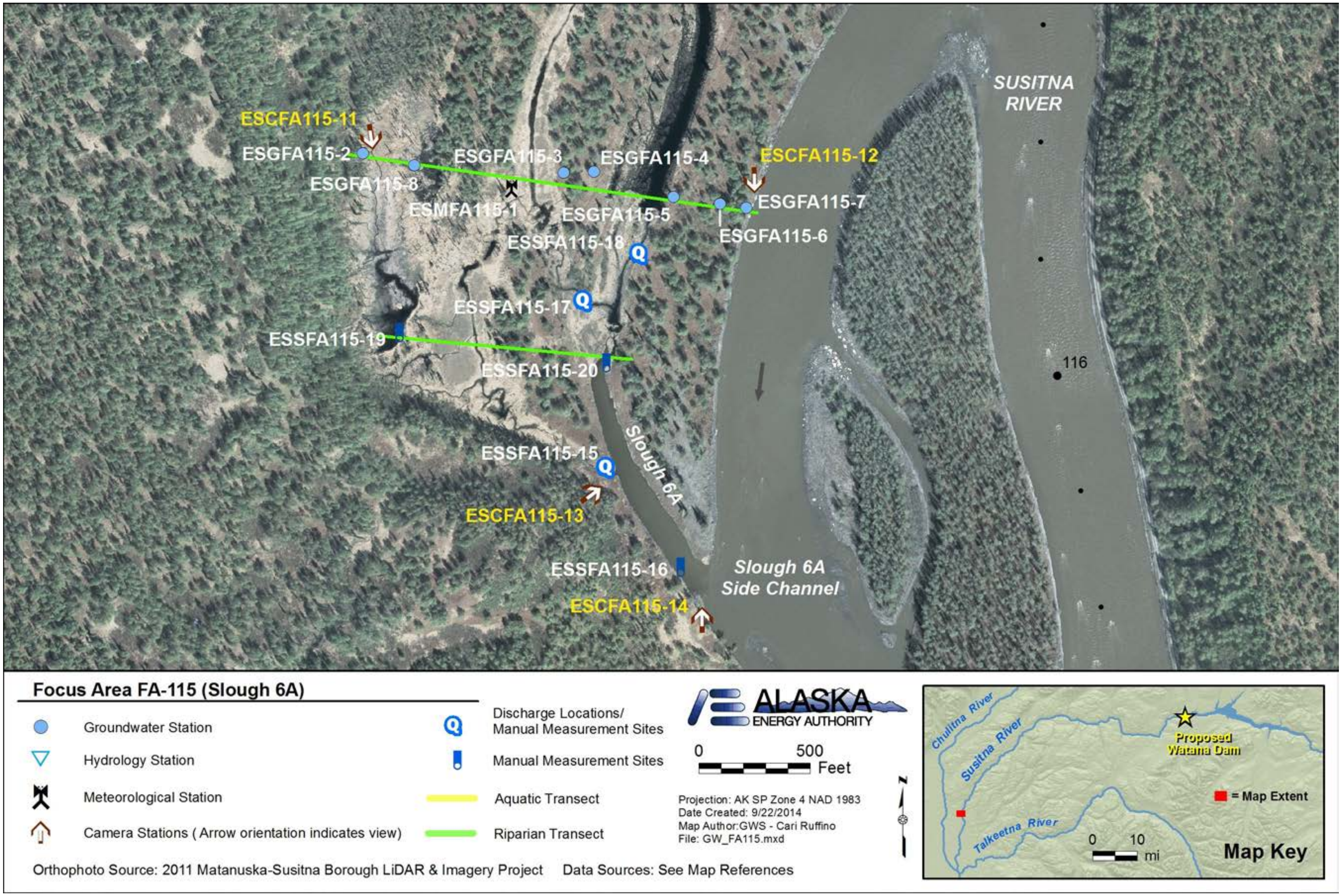


Figure 15. General location of FA-115 (Slough 6A) Focus Area, showing major data collection stations and aquatic and riparian transects.

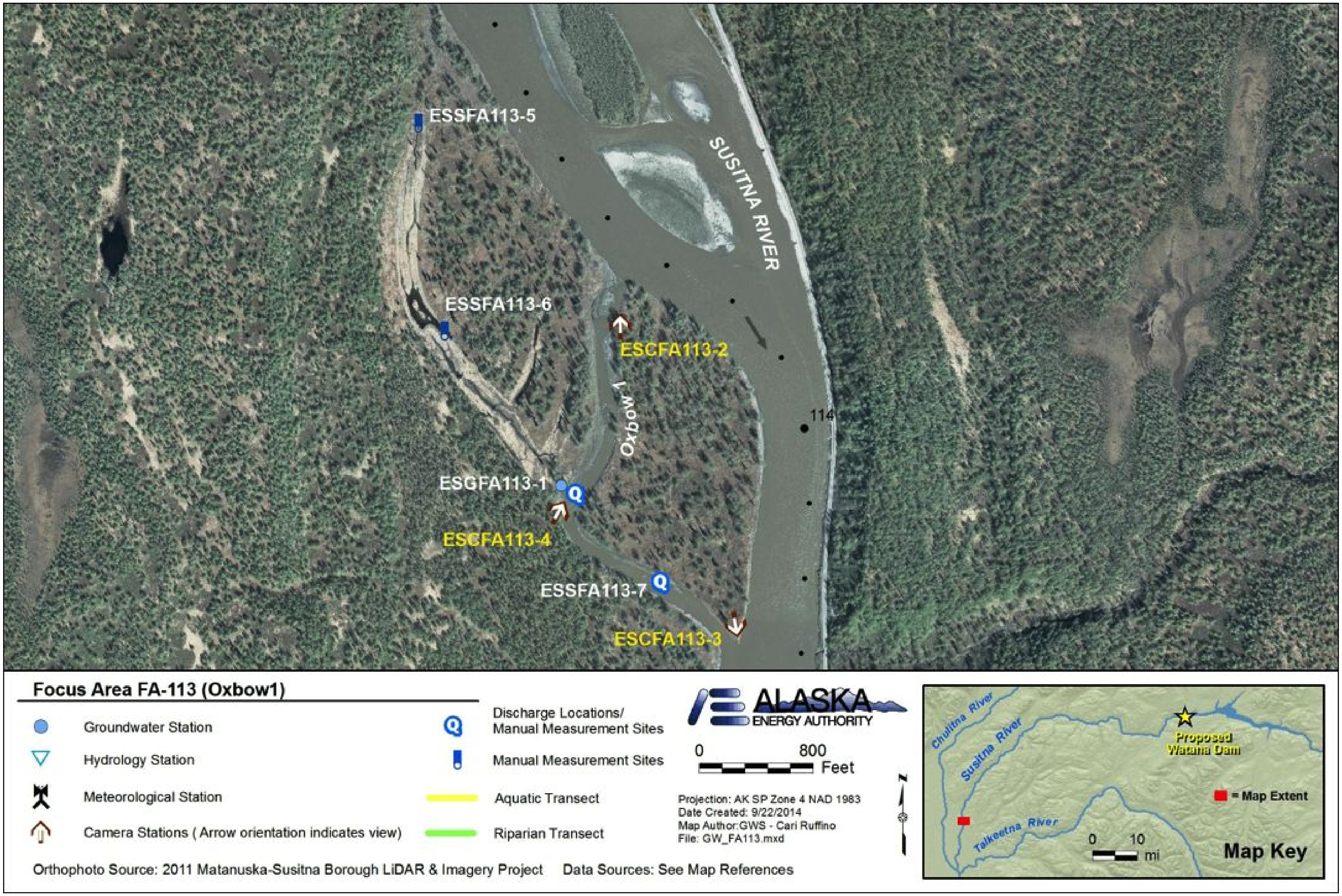


Figure 16. General location of FA-113 (Oxbow 1) Focus Area, showing major data collection stations.

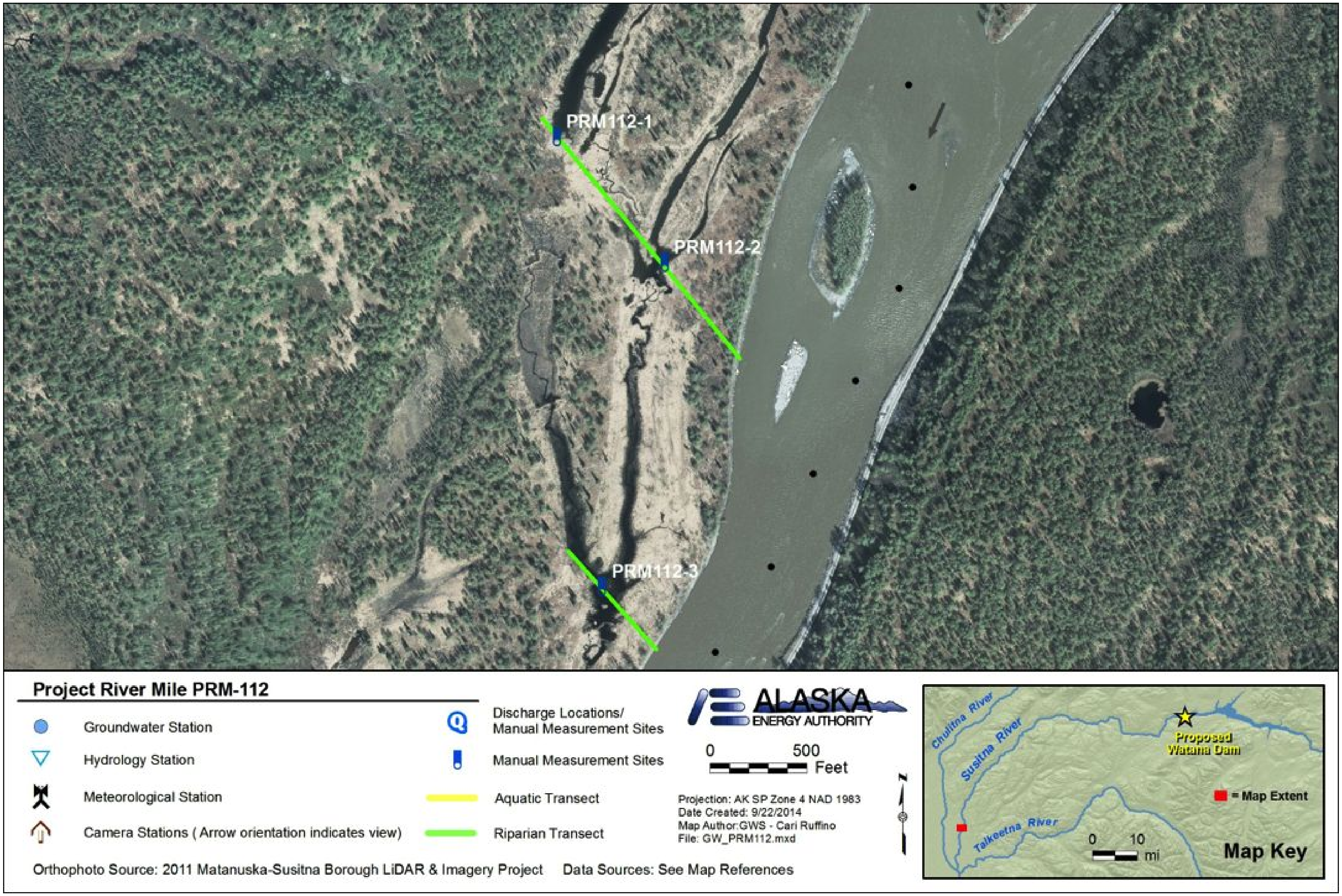


Figure 17. General location of PRM 112 (Project River Mile), showing the data collection stations and riparian transects.

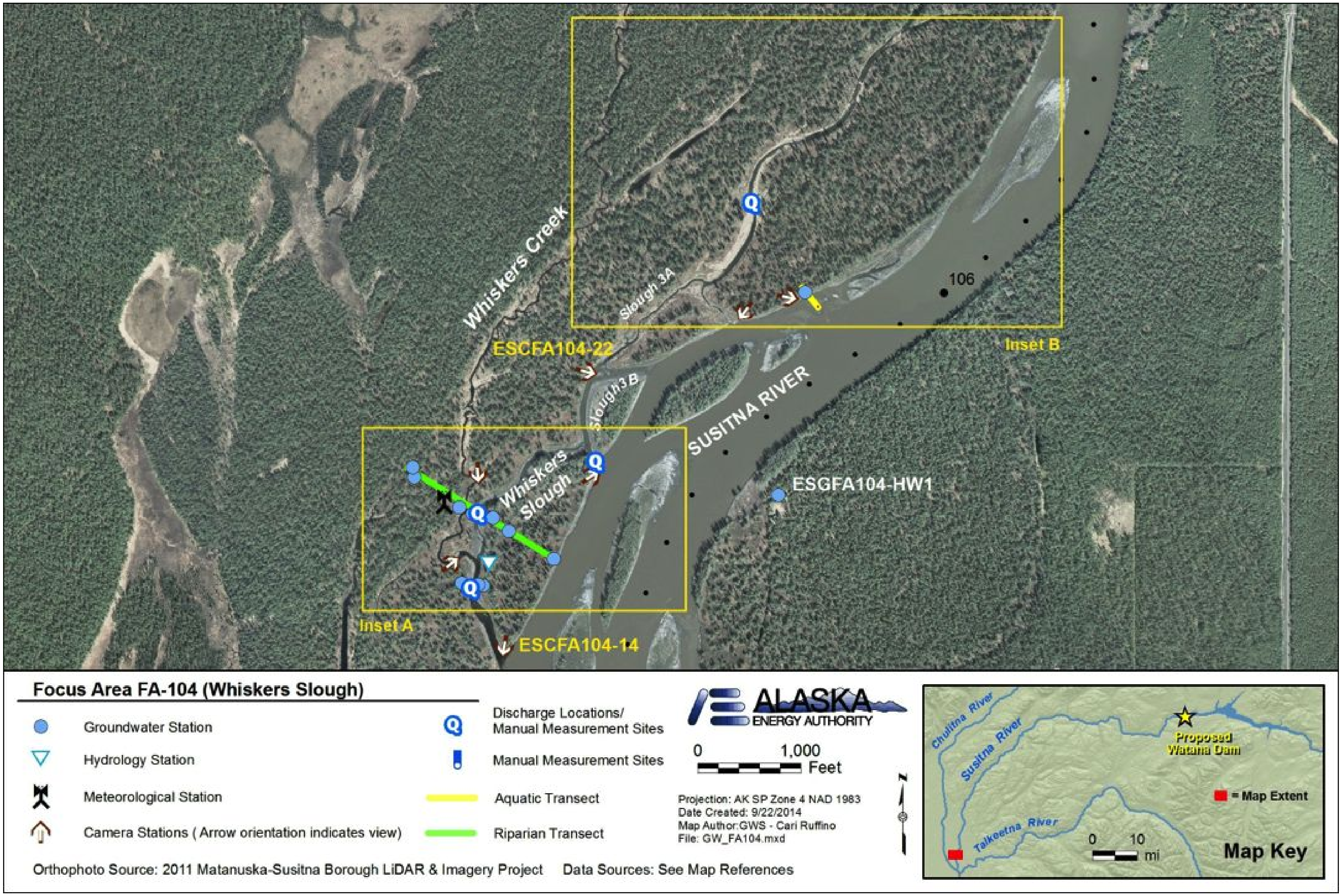


Figure 18. General location of FA-104 (Whiskers Slough) Focus Area, showing major data collection stations and aquatic and riparian transects.

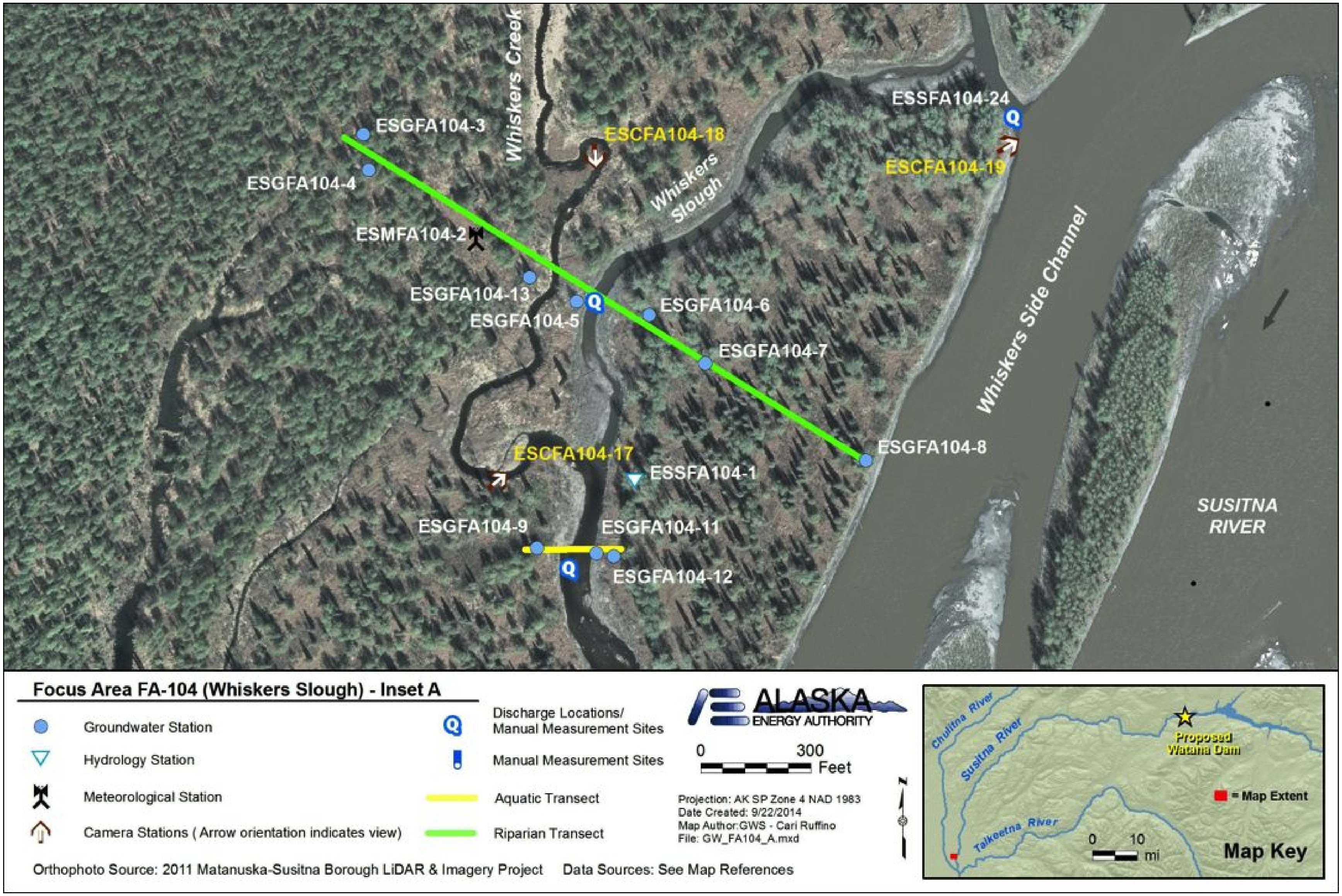


Figure 19. Inset A shows locations of aquatic transect stations with continuously measured parameters at FA-104 (Whiskers Slough) Focus Area.

Figure 20. Inset B shows locations of aquatic transect stations with continuously measured parameters at FA-104 (Whiskers Slough) Focus Area.

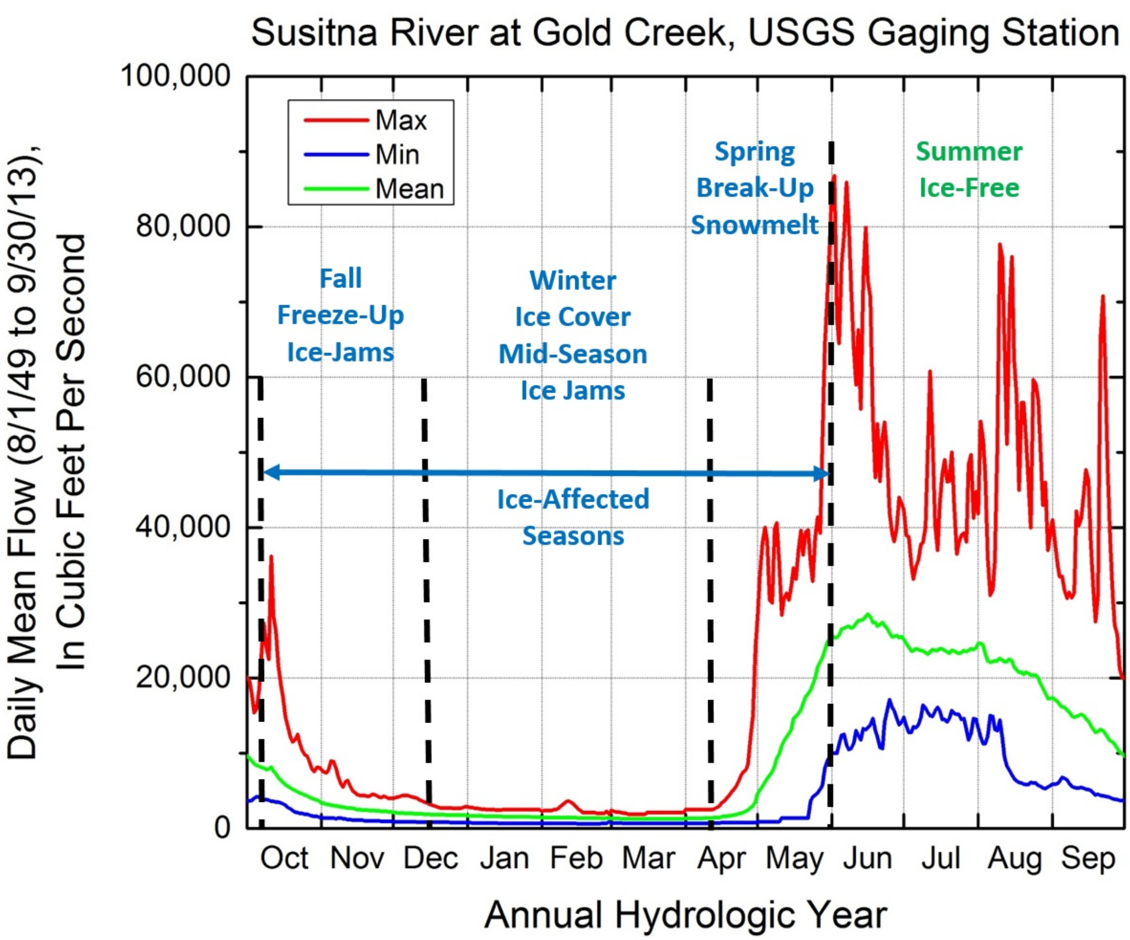


Figure 21. Annual hydrologic periods and period of record flow conditions for Susitna River at Gold Creek (PRM 140.0).

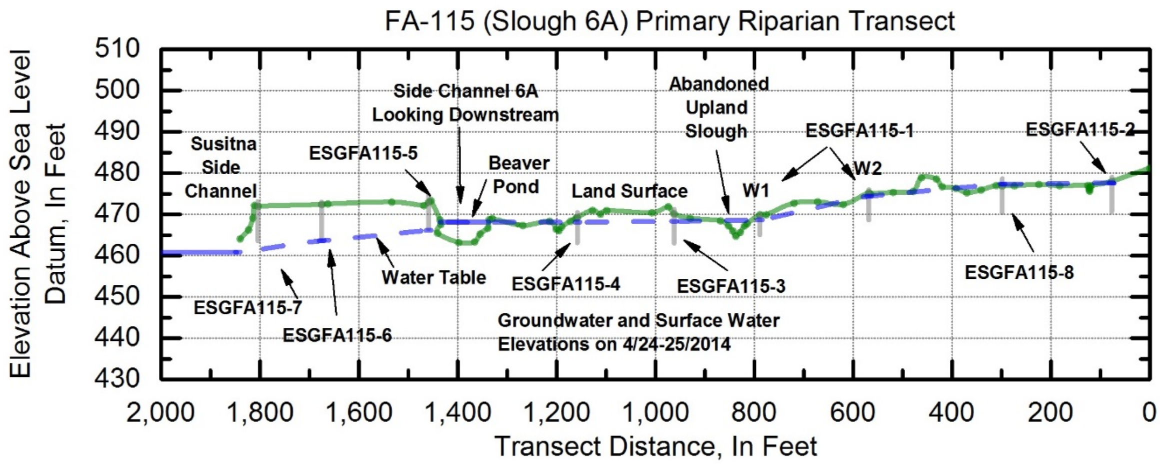


Figure 22. Primary riparian cross section at FA-115 (Slough 6A) showing location of groundwater wells, surface-water measurement locations, and the measured water levels on April 24-25, 2014, with inferred water table.

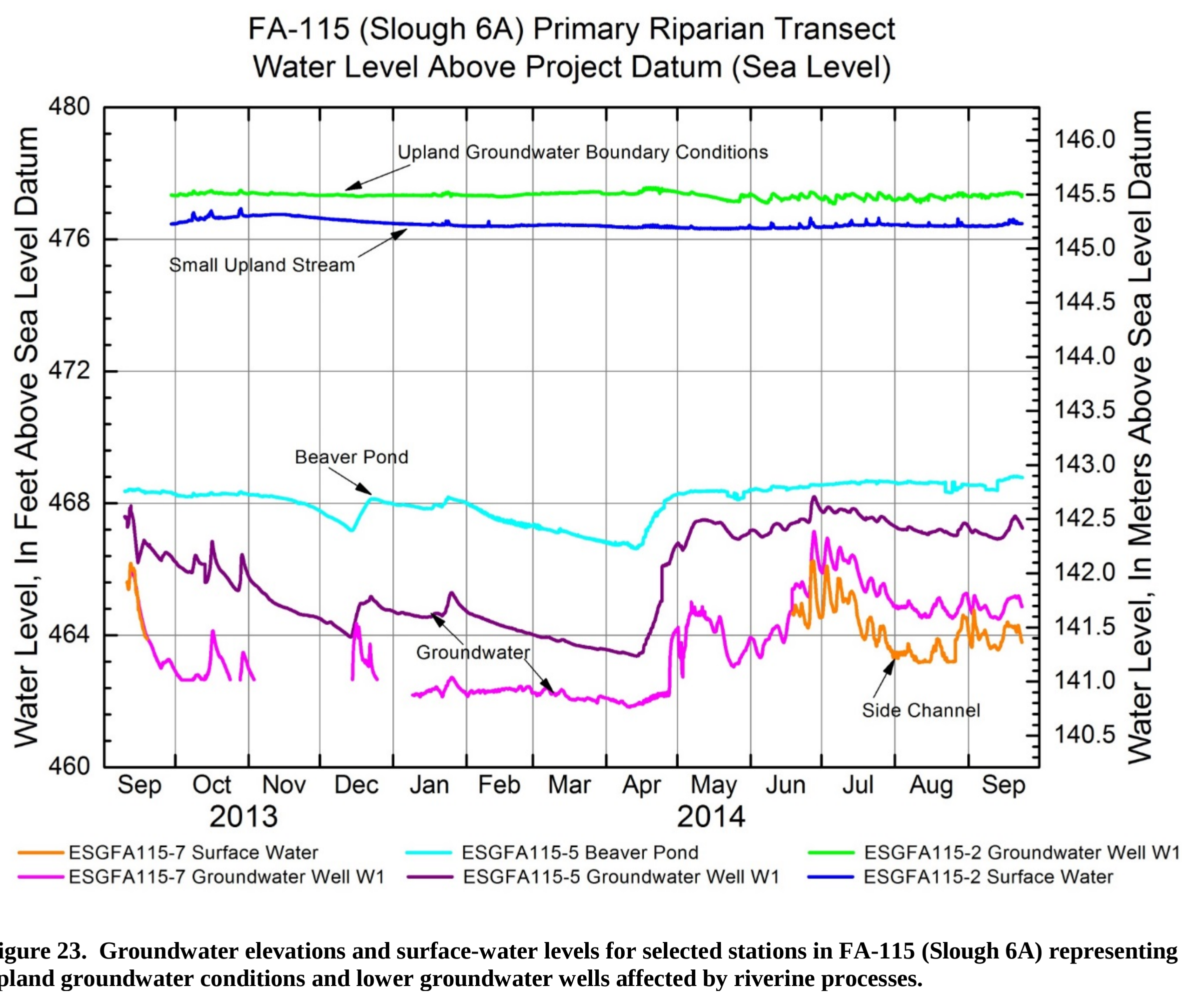


Figure 23. Groundwater elevations and surface-water levels for selected stations in FA-115 (Slough 6A) representing upland groundwater conditions and lower groundwater wells affected by riverine processes.

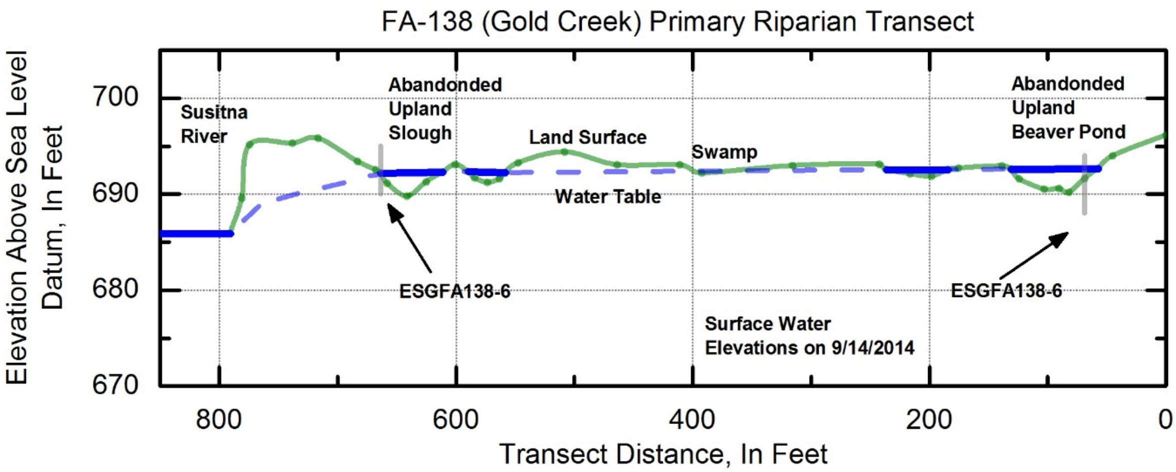


Figure 24. Primary riparian cross section at FA-138 (Gold Creek) showing locations of surface-water measurement locations, and typical upland features that indicate shallow groundwater conditions. Water levels are shown for the cross-section survey date of 9/14/2014.

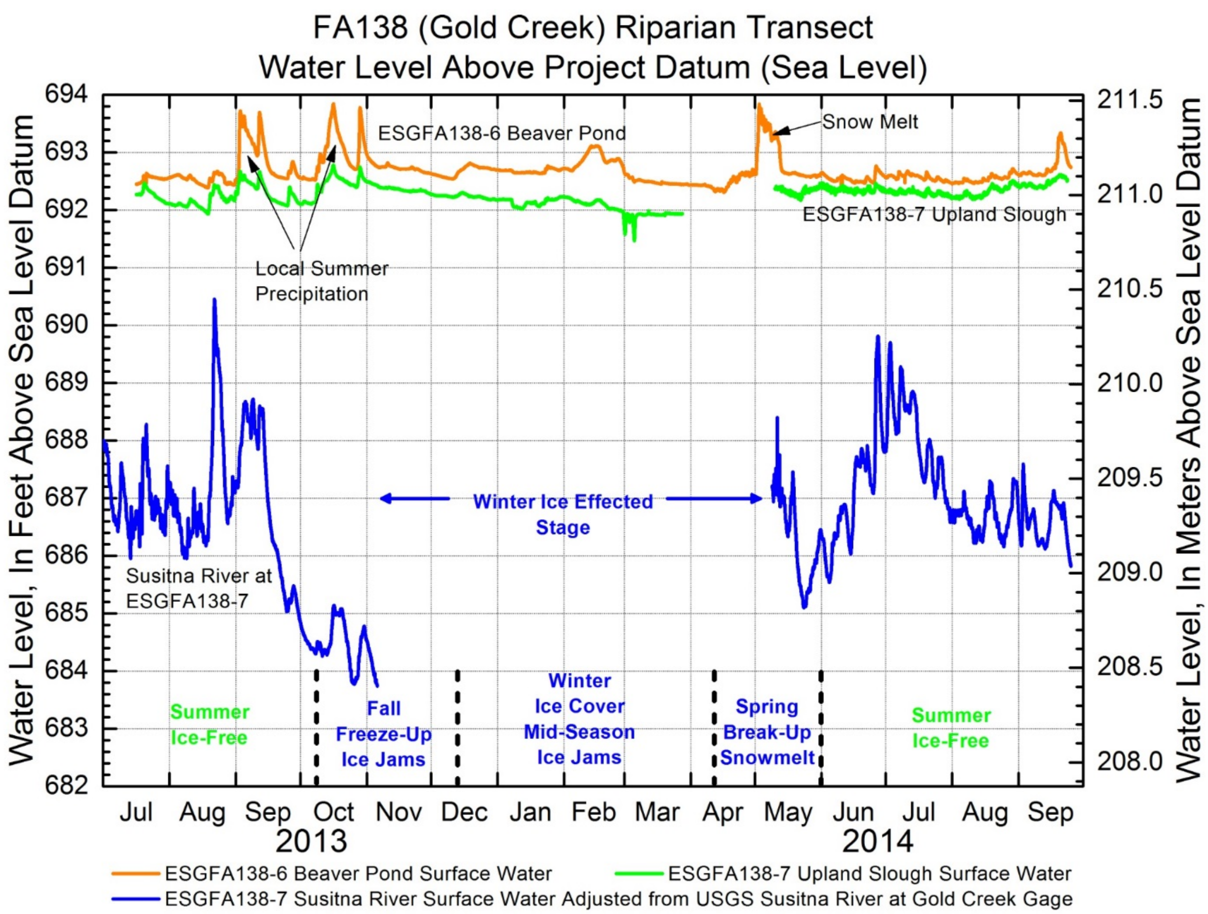


Figure 25. Surface-water levels for stations in the FA-138 (Gold Creek) riparian transect. Major hydrologic periods are indicated to show how the variation in water levels relate to the climate and hydrologic processes relevant to these periods.

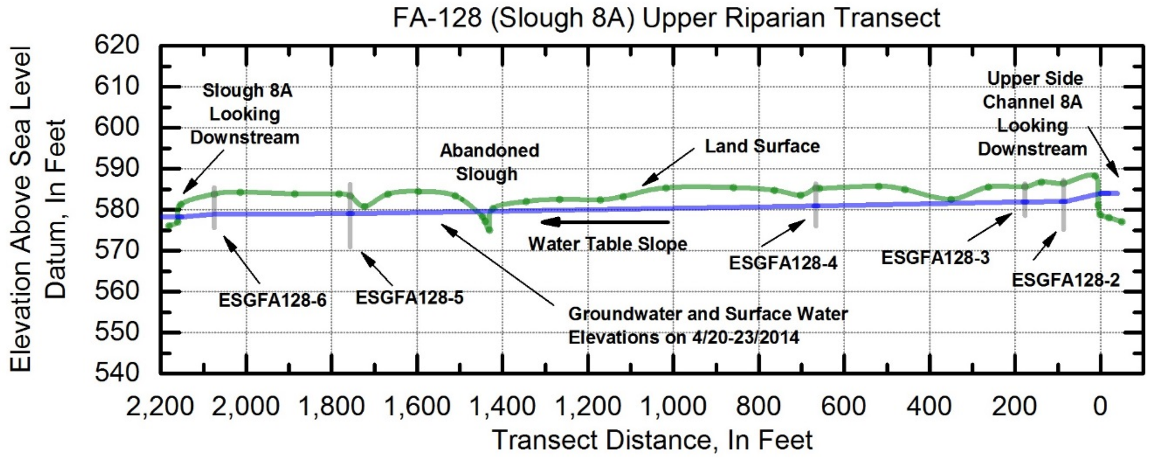


Figure 26. Cross-section profile of the Upper Riparian Transect in FA-128 (Slough 8A) showing the land surface profile, location of groundwater wells and surface water measuring points on Upper Side Channel 8A and Slough 8A. Water levels are shown for the April 20-23, 2014. Water levels in Upper Side Channel 8A are ice affected.

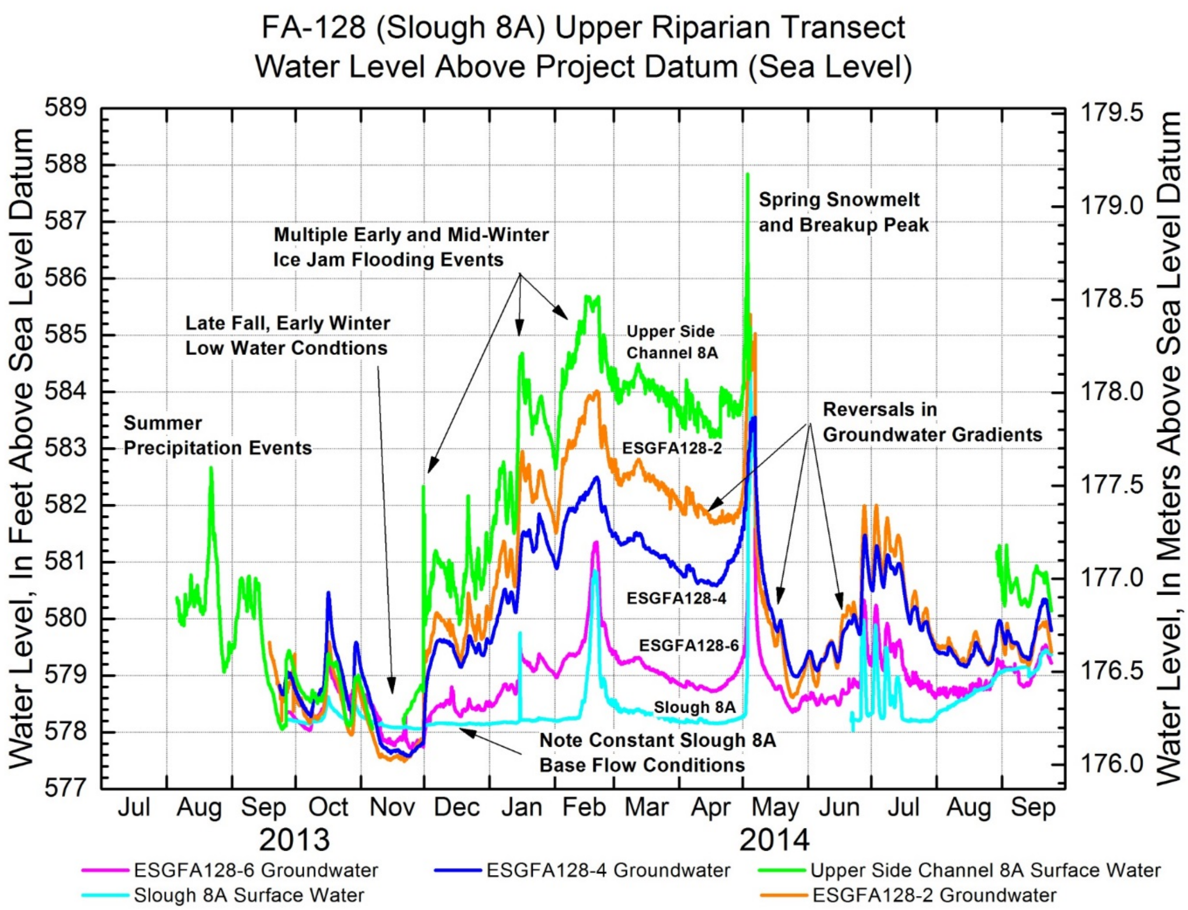


Figure 27. Water level data for Upper Side Channel 8A, Slough 8A, and groundwater wells between the two surface-water features on the Upper Riparian Transect in FA-128 (Slough 8A).

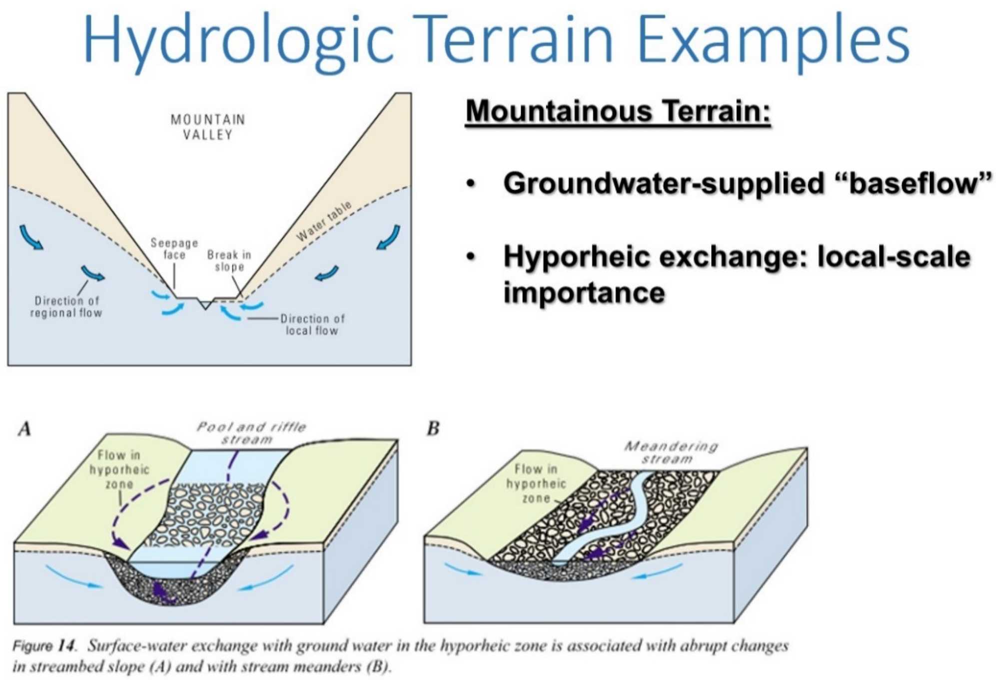


Figure 28. Hydrologic terrain examples for mountainous terrain and local-scale hyporheic scale processes (Winter 1998).

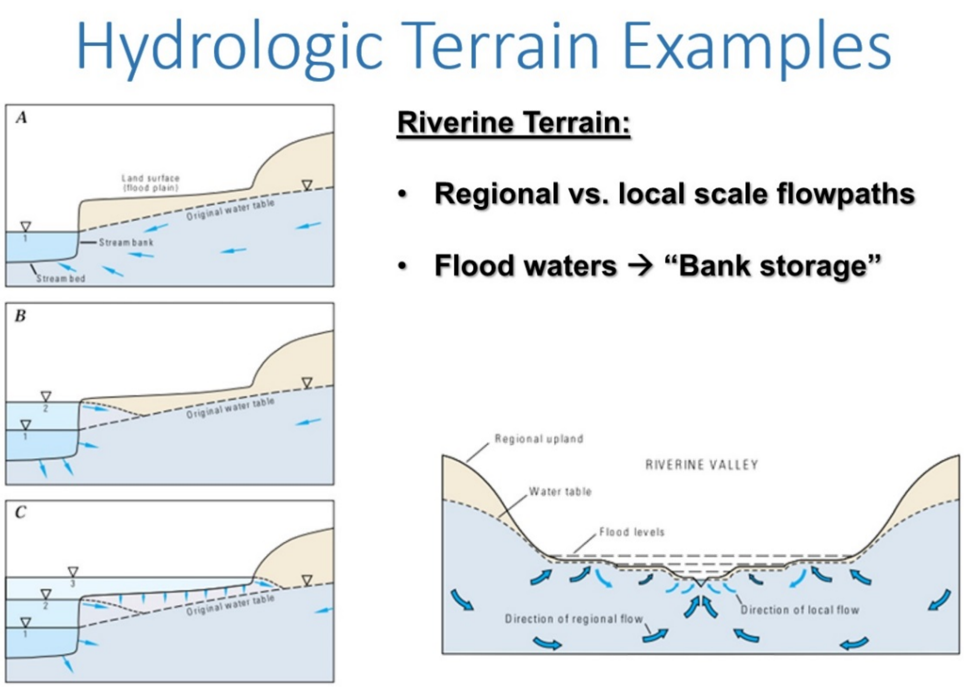


Figure 29. Hydrologic terrain examples for riverine terrain and local-scale floodplain processes (Winter 1998).

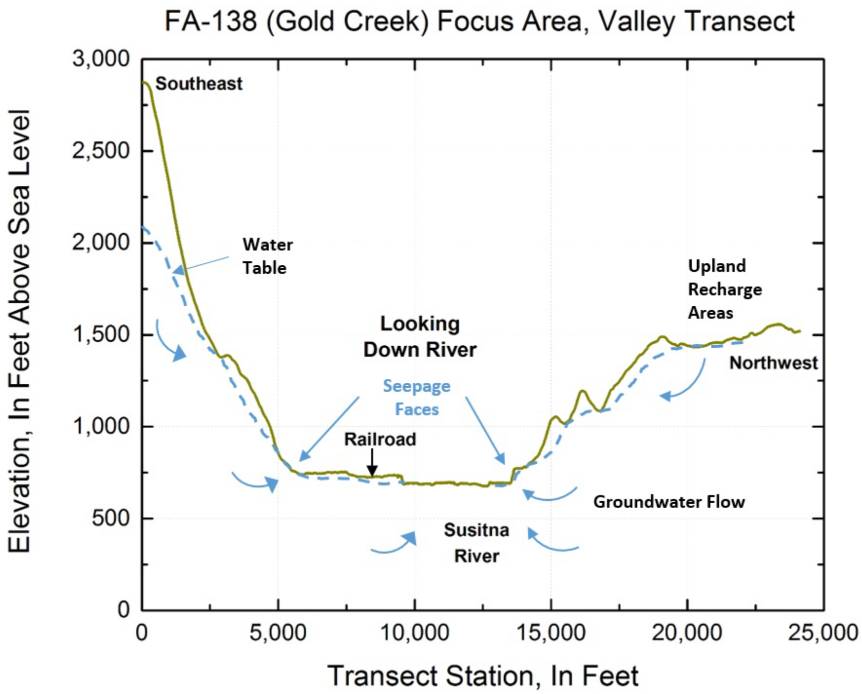


Figure 30. Conceptual groundwater and surface water processes on a valley transect at FA-138 (Gold Creek) at a valley scale.

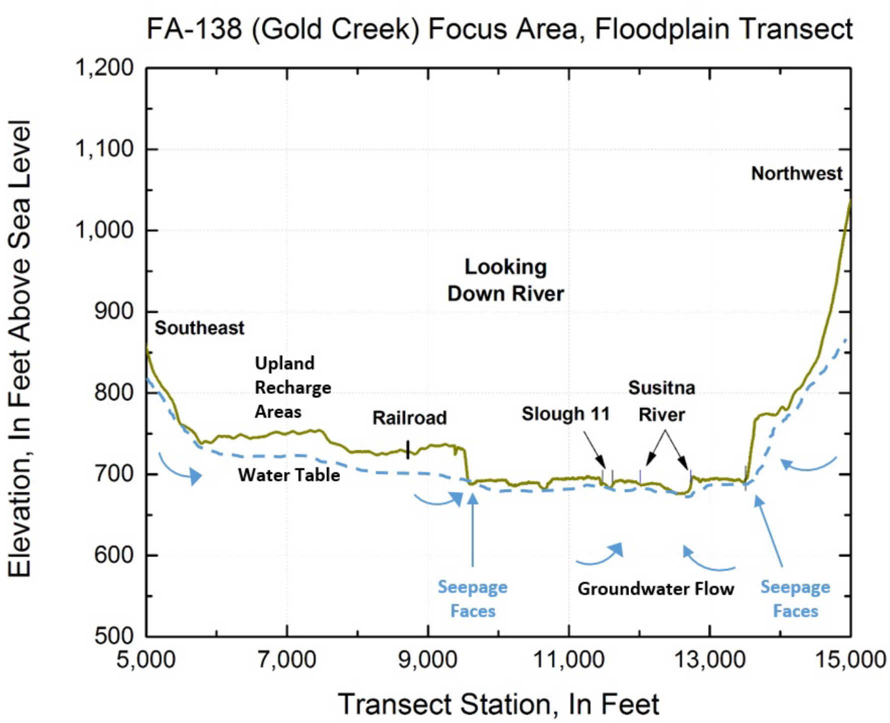


Figure 31. Conceptual groundwater and surface water processes on a valley transect at FA-138 (Gold Creek) at a broad floodplain scale showing adjacent older terraces.

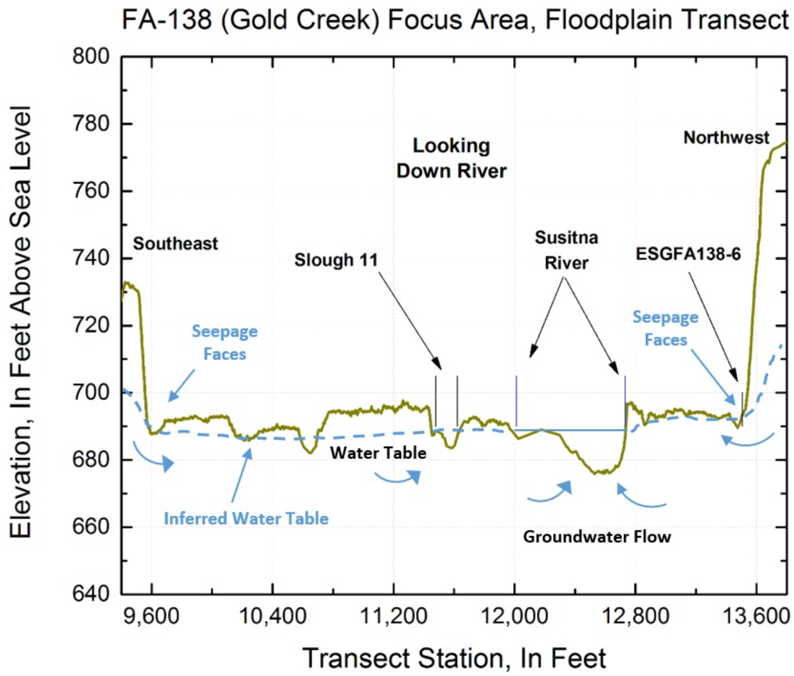


Figure 32. Conceptual groundwater and surface water processes on a valley transect at FA-138 (Gold Creek) at a narrow floodplain scale showing relationships of river levels, shallow water tables in the floodplain and seepage faces at slope breaks where springs are commonly seen.

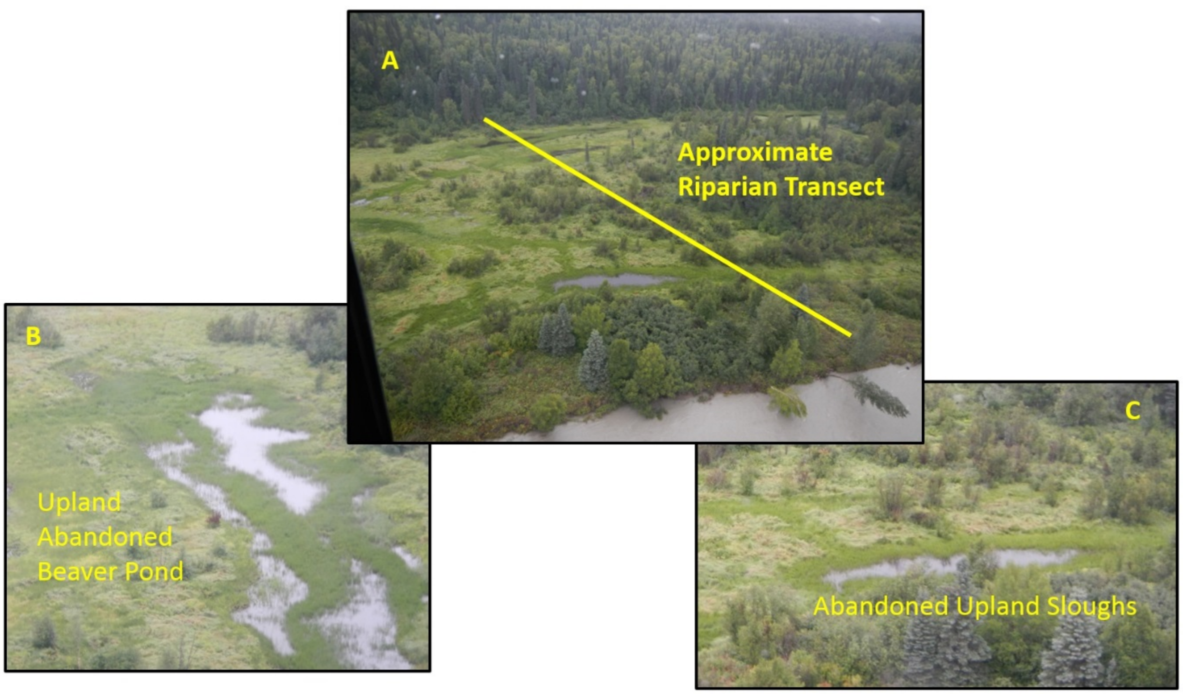


Figure 33. Aerial images of the terrain hydrology and riparian cover at FA-138 (Gold Creek) located on the right bank (looking downstream). Images were taken August 22, 2013. (a) Shows the general location of the FA-138 Riparian transect, which goes from the edge of the Susitna River across the upland terrace and crosses abandoned sloughs and beaver ponds that are against the hill slope. (b) View of the abandoned beaver pond, developed in an old slough. (c) View of an abandoned slough, adjacent and above the Susitna River.

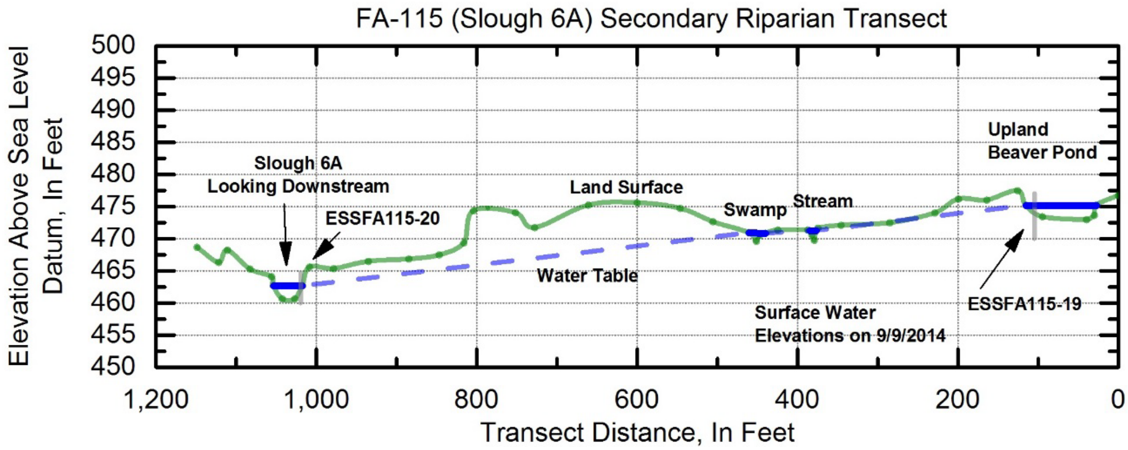


Figure 34. Secondary riparian cross section at FA-115 (Slough 6A) showing location of surface-water measurement locations and the measured water levels on April 24-25, 2014 with inferred water table. This transect is an example transect for applying lateral hydraulic gradients within a Focus Area.

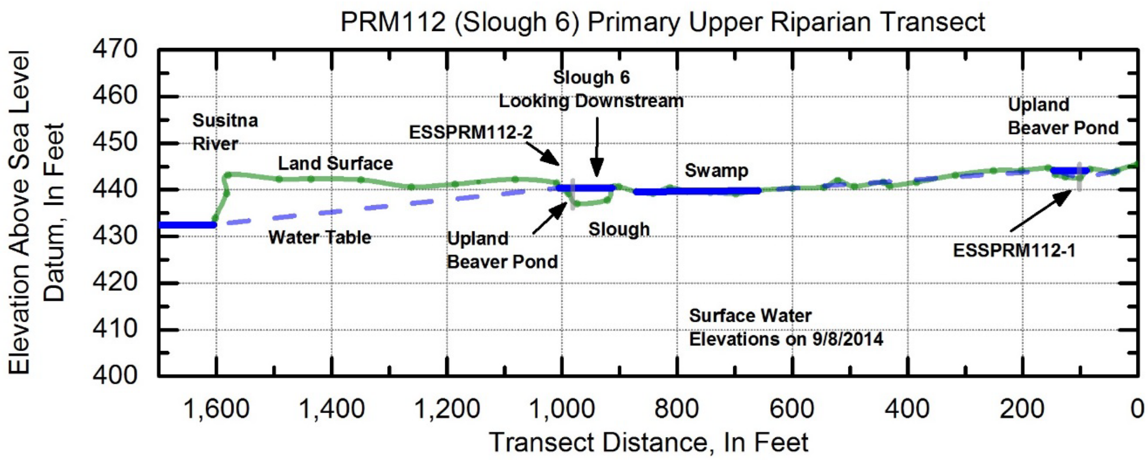


Figure 35. Primary Riparian Cross Section at PRM-112 (Project River Mile). This transect is an example transect for applying lateral hydraulic gradients outside a Focus Area.

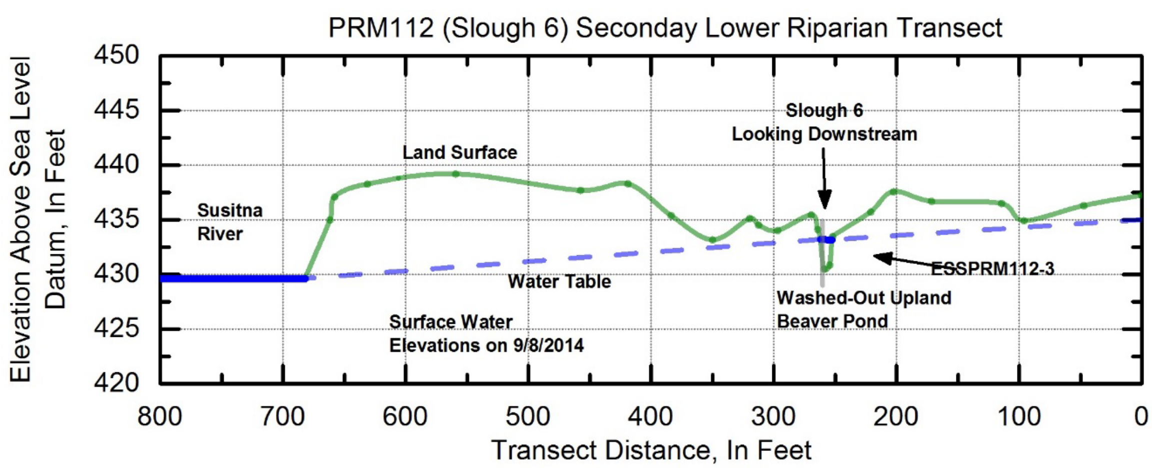
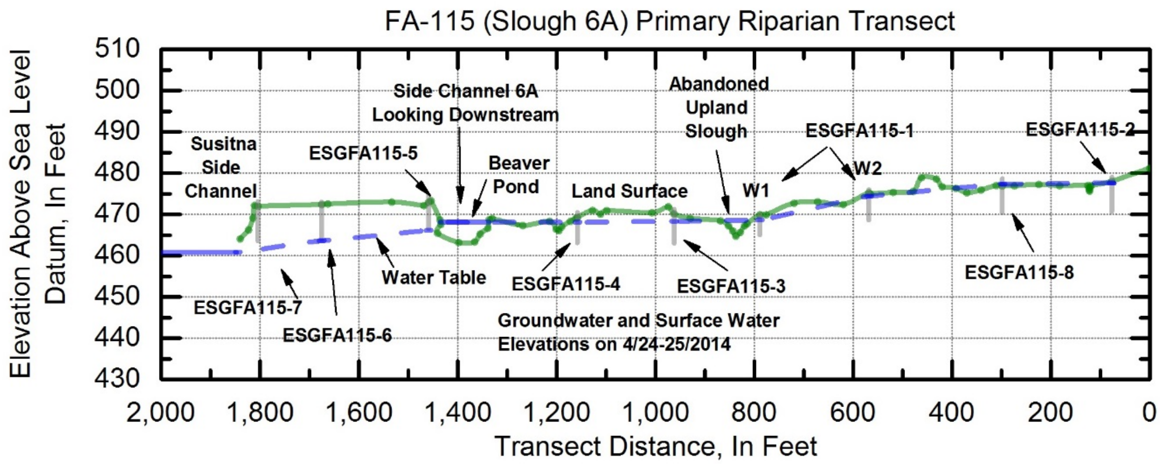


Figure 36. Secondary Riparian Cross Section at PRM-112 (Project River Mile). This transect is an example transect for applying lateral hydraulic gradients outside a Focus Area.



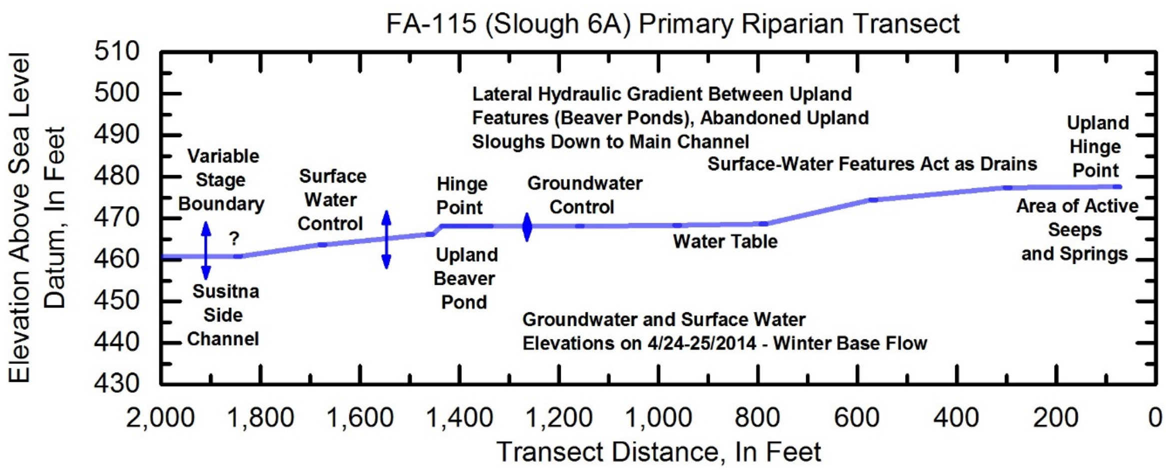


Figure 37. Primary riparian cross section at FA-115 (Slough 6A) showing location of groundwater wells, surface-water measurement locations, and the measured water levels on April 24-25, 2014 with inferred water table and the associated lateral hydraulic gradient diagram showing the hydrologic features for defining hydrology characteristics in terms of lateral hydraulic gradients.

APPENDIX A. HYDROLOGIC STATIONS PRIMARY STATION PURPOSE, LOCATION AND DATA COLLECTION PARAMETERS

Table 1. Groundwater Study primary station purpose, location and data collection parameters for hydrologic stations at FA-144 (Slough 21).

SuWa Groundwater Study
Focus Area Station Locations
Last Update: 20140912 HESnyderman

Note: The following are QC3 station coordinates for data collection stations in Focus Areas (FA). Specific locations for wells, surface-water pressure transducers, and other sensors are provided in other files.

Data Collection Parameters: air temperature, AT; camera images, Cam; groundwater level, GWL; groundwater temperature, GWT; groundwater conductivity GWC; net radiation, NR, relative humidity, RH; sap flow, SF; soil heat flux, SHF; soil-moisture profile, SMP; soil-temperature profile, SoTP; streambed temperature profile, STP; summer precipitation, SP; solar radiation, SR; surface-water conductivity, SWC, surface-water height, GH; manual surface-water height, WSE; surface-water temperature, WT; wind direction, WD; wind speed, WS; manual discharge, Q. A (#) indicates more than one measurement location.

Focus Area: FA-144 (Slough 21)

Station Short Names	Station Primary Purpose	Latitude	Longitude	Data Collection Parameters
ESSFA144-1	Surface Water	62.81376	149.57600	WSE, Q
ESSFA144-2	Surface Water	62.81475	149.57397	WSE
ESSFA144-3	Surface Water	62.81541	149.57479	WSE, Q
ESSFA144-4	Surface Water	62.80708	149.59206	WSE

Table 2. Groundwater Study primary station purpose, location and data collection parameters for hydrologic stations at FA-141 (Indian River).

SuWa Groundwater Study
Focus Area Station Locations
Last Update: 20140912 HESnyderman

Note: The following are QC3 station coordinates for data collection stations in Focus Areas (FA). Specific locations for wells, surface-water pressure transducers, and other sensors are provided in other files.

Data Collection Parameters: air temperature, AT; camera images, Cam; groundwater level, GWL; groundwater temperature, GWT; groundwater conductivity GWC; net radiation, NR, relative humidity, RH; sap flow, SF; soil heat flux, SHF; soil-moisture profile, SMP; soil-temperature profile, SoTP; streambed temperature profile, STP; summer precipitation, SP; solar radiation, SR; surface-water conductivity, SWC, surface-water height, GH; manual surface-water height, WSE; surface-water temperature, WT; wind direction, WD; wind speed, WS; manual discharge, Q. A (#) indicates more than one measurement location.

Focus Area: FA-141 (Indian River)

Station Short Names	Station Primary Purpose	Latitude	Longitude	Data Collection Parameters
ESSFA141-1	Surface Water	62.78816	149.65007	WSE
ESSFA141-2	Surface Water	62.79001	149.64375	WSE
ESSFA141-3	Surface Water	62.78137	149.69116	WSE
ESSFA141-4	Surface Water	62.78030	149.68943	WSE
ESSFA141-5	Surface Water	62.77985	149.68854	WSE

Table 3. Groundwater Study primary station purpose, location and data collection parameters for hydrologic stations at FA-138 (Gold Creek).

SuWa Groundwater Study
Focus Area Station Locations
Last Update: 20140912 HESnyderman

Note: The following are QC3 station coordinates for data collection stations in Focus Areas (FA). Specific locations for wells, surface-water pressure transducers, and other sensors are provided in other files.

Data Collection Parameters: air temperature, AT; camera images, Cam; groundwater level, GWL; groundwater temperature, GWT; groundwater conductivity GWC; net radiation, NR, relative humidity, RH; sap flow, SF; soil heat flux, SHF; soil-moisture profile, SMP; soil-temperature profile, SoTP; streambed temperature profile, STP; summer precipitation, SP; solar radiation, SR; surface-water conductivity, SWC, surface-water height, GH; manual surface-water height, WSE; surface-water temperature, WT; wind direction, WD; wind speed, WS; manual discharge, Q. A (#) indicates more than one measurement location.

Focus Area: FA-138 (Gold Creek)

Station Short Names	Station Primary Purpose	Latitude	Longitude	Data Collection Parameters
ESGFA138-1	Groundwater	62.75758	149.70694	AT, GWL(2), GWT(2), GH, WT, STP, SWC, SP, WSE, Q
ESGFA138-2	Groundwater	62.76464	149.70595	GWL(2), GWT(2), GH, WT, STP, SWC, WSE, Q
ESGFA138-3	Groundwater	62.75675	149.70559	GWL, GWT
ESGFA138-4	Groundwater	62.76513	149.70604	GWL, GWT
ESGFA138-5	Groundwater	62.76555	149.70621	GWL, GWT
ESGFA138-6	Groundwater	62.76934	149.70984	GH, WT
ESGFA138-7	Groundwater	62.76779	149.70720	GH, WT
ESCFA138-8	Camera	62.75268	149.70792	Cam
ESCFA138-9	Camera	62.75686	149.70529	Cam
ESCFA138-10	Camera	62.76477	149.70522	Cam
ESCFA138-11	Camera	62.76770	149.70755	Cam
ESSFA138-12	Surface Water	62.76659	149.71334	WSE
ESSFA138-13	Surface Water	62.76579	149.71357	WSE, Q
ESSFA138-14	Surface Water	62.75670	149.70626	WSE, Q
ESSFA138-15	Surface Water	62.76243	149.70079	WSE, Q
ESSFA138-16	Surface Water	62.75416	149.70764	WSE, Q
ESSFA138-17	Surface Water	62.76027	149.69916	WSE, Q

Table 4. Groundwater Study primary station purpose, location and data collection parameters for hydrologic stations at FA-128 (Slough 8A).

SuWa Groundwater Study

Focus Area Station Locations

Last Update: 20140912 HFSnyderman

Note: The following are QC3 station coordinates for data collection stations in Focus Areas (FA). Specific locations for wells, surface-water pressure transducers, and other sensors are provided in other files.

Data Collection Parameters: air temperature, AT; camera images, Cam; groundwater level, GWL; groundwater temperature, GWT; groundwater conductivity GWC; net radiation, NR, relative humidity, RH; sap flow, SF; soil heat flux, SHF; soil-moisture profile, SMP; soil-temperature profile, SoTP; streambed temperature profile, STP; summer precipitation, SP; solar radiation, SR; surface-water conductivity, SWC, surface-water height, GH; manual surface-water height, WSE; surface-water temperature, WT; wind direction, WD; wind speed, WS; manual discharge, Q. A (#) indicates more than one measurement location.

Focus Area: FA-128 (Slough 8A)

Station Short Names	Station Primary Purpose	Latitude	Longitude	Data Collection Parameters
ESSFA128-1	Surface Water	62.66384	149.90494	AT, GH, WT, STP, Cam, WSE, Q
ESGFA128-2	Groundwater	62.67204	149.89403	GWL, GWT, GH, WT
ESGFA128-3	Groundwater	62.67179	149.89390	GWL, GWT, SF
ESGFA128-4	Groundwater	62.67049	149.89341	GWL, GWT
ESGFA128-5	Groundwater	62.66765	149.89352	GWL, GWT, GH, WT, SF, WSE, Q
ESGFA128-6	Groundwater	62.66660	149.89320	GWL, GWT, GH, WT
ESGFA128-7	Groundwater	62.66550	149.89707	GWL(2), GWT(2), GWC, GH, WT, SWC, STP, WSE, Q
ESMFA128-8	Meteorological	62.67052	149.89485	AT, RH, SMP, SR, SoTP, SHF, WD, WS
ESGFA128-9	Groundwater	62.66349	149.90730	GWL(2), GWT(2), SF
ESGFA128-10	Groundwater	62.66393	149.90766	GWL, GWT, SF
ESGFA128-11	Groundwater	62.66596	149.91077	GWL, GWT, GH, WT
ESGFA128-12	Groundwater	62.66711	149.91272	GWL, GWT, GH, WT
ESGFA128-13	Groundwater	62.68626	149.90953	GWL(2), GWT(2), GWC, GH, WT, SWC, STP
ESSFA128-14	Surface Water	62.67271	149.89112	GH, WT
ESSFA128-15	Surface Water	62.67273	149.88573	GH, WT
ESSFA128-16	Surface Water	62.67015	149.88548	GH, WT
ESSFA128-17	Surface Water	62.66888	149.88480	GH, WT
ESGFA128-18	Groundwater	62.66538	149.89694	GWL, GWT
ESGFA128-19	Groundwater	62.66525	149.89681	GWL, GWT
ESGFA128-20	Groundwater	62.66305	149.90938	GWL, GWT
ESGFA128-21	Groundwater	62.66485	149.90892	GWL, GWT
ESGFA128-22	Groundwater	62.66088	149.91993	GH, WT
ESGFA128-23	Groundwater	62.66466	149.91168	GWL, GWT
ESGFA128-24	Groundwater	62.66534	149.90681	GWL, GWT

Table 4. Groundwater Study primary station purpose, location and data collection parameters for hydrologic stations at FA-128 (Slough 8A), continued.

SuWa Groundwater Study

Focus Area Station Locations

Last Update: 20140912 HFSnyderman

Note: The following are QC3 station coordinates for data collection stations in Focus Areas (FA). Specific locations for wells, surface-water pressure transducers, and other sensors are provided in other files.

Data Collection Parameters: air temperature, AT; camera images, Cam; groundwater level, GWL; groundwater temperature, GWT; groundwater conductivity GWC; net radiation, NR, relative humidity, RH; sap flow, SF; soil heat flux, SHF; soil-moisture profile, SMP; soil-temperature profile, SoTP; streambed temperature profile, STP; summer precipitation, SP; solar radiation, SR; surface-water conductivity, SWC, surface-water height, GH; manual surface-water height, WSE; surface-water temperature, WT; wind direction, WD; wind speed, WS; manual discharge, Q. A (#) indicates more than one measurement location.

Focus Area: FA-128 (Slough 8A)

Station Short Names	Station Primary Purpose	Latitude	Longitude	Data Collection Parameters
FSGFA128-25	Groundwater	62.66767	149.90671	GWL, GWT
FSGFA128-26	Groundwater	62.66946	149.89789	GWL, GWT
FSGFA128-27	Groundwater	62.67092	149.88946	GWL, GWT
FSCFA128-29	Camera	62.67251	149.88567	Cam
FSCFA128-30	Camera	62.66804	149.88652	Cam
FSCFA128-31	Camera	62.66549	149.89812	Cam
FSCFA128-32	Camera	62.66754	149.89376	Cam
FSCFA128-33	Camera	62.67179	149.89376	Cam
FSCFA128-34	Camera	62.66719	149.91216	Cam
FSCFA128-35	Camera	62.66307	149.91039	Cam
FSCFA128-36	Camera	62.66167	149.91676	Cam
FSSFA128-37	Surface Water	62.66764	149.89858	WSE, Q
FSSFA128-38	Surface Water	62.66788	149.88809	WSE, Q
FSSFA128-39	Surface Water	62.66289	149.92729	WSE
FSSFA128-40	Surface Water	62.66469	149.92282	WSE

Table 5. Groundwater Study primary station purpose, location and data collection parameters for hydrologic stations at FA-115 (Slough 6A).

SuWa Groundwater Study
Focus Area Station Locations
Last Update: 20140912 HESnyderman

Note: The following are QC3 station coordinates for data collection stations in Focus Areas (FA). Specific locations for wells, surface-water pressure transducers, and other sensors are provided in other files.

Data Collection Parameters: air temperature, AT; camera images, Cam; groundwater level, GWL; groundwater temperature, GWT; groundwater conductivity GWC; net radiation, NR, relative humidity, RH; sap flow, SF; soil heat flux, SHF; soil-moisture profile, SMP; soil-temperature profile, SoTP; streambed temperature profile, STP; summer precipitation, SP; solar radiation, SR; surface-water conductivity, SWC, surface-water height, GH; manual surface-water height, WSE; surface-water temperature, WT; wind direction, WD; wind speed, WS; manual discharge, Q. A (#) indicates more than one measurement location.

Focus Area: FA-115 (Slough 6A)

Station Short Names	Station Primary Purpose	Latitude	Longitude	Data Collection Parameters
ESMFA115-1	Meteorological	62.51892	150.12688	AT, RH, SMP, SR, SoTP, SHF, GWL(2), GWT(2), WD, WS
ESGFA115-2	Groundwater	62.51929	150.13084	GWL, GWT, GH, WT
ESGFA115-3	Groundwater	62.51905	150.12550	GWL, GWT, GH, WT
ESGFA115-4	Groundwater	62.51906	150.12470	GWL, GWT
ESGFA115-5	Groundwater	62.51876	150.12258	GWL, GWT, GH, WT
ESGFA115-6	Groundwater	62.51868	150.12135	GWL, GWT
ESGFA115-7	Groundwater	62.51863	150.12064	GWL, GWT, GH, WT
ESGFA115-8	Groundwater	62.51914	150.12948	GWL, GWT
ESCFA115-11	Camera	62.51933	150.13072	Cam
ESCFA115-12	Camera	62.51896	150.12046	Cam
ESCFA115-13	Camera	62.51507	150.12476	Cam
ESCFA115-14	Camera	62.51357	150.12182	Cam
ESSFA115-15	Surface Water	62.51543	150.12440	WSE, Q
ESSFA115-16	Surface Water	62.51414	150.12244	WSE
ESSFA115-17	Surface Water	62.51746	150.12512	WSE, Q
ESSFA115-18	Surface Water	62.51806	150.12353	WSE, Q
ESSFA115-19	Surface Water	62.51704	150.12990	WSE
ESSFA115-20	Surface Water	62.51676	150.12446	WSE

Table 6. Groundwater Study primary station purpose, location and data collection parameters for hydrologic stations at FA-113 (Oxbow 1).

SuWa Groundwater Study
Focus Area Station Locations
Last Update: 20140912 HESnyderman

Note: The following are QC3 station coordinates for data collection stations in Focus Areas (FA). Specific locations for wells, surface-water pressure transducers, and other sensors are provided in other files.

Data Collection Parameters: air temperature, AT; camera images, Cam; groundwater level, GWL; groundwater temperature, GWT; groundwater conductivity GWC; net radiation, NR, relative humidity, RH; sap flow, SF; soil heat flux, SHF; soil-moisture profile, SMP; soil-temperature profile, SoTP; streambed temperature profile, STP; summer precipitation, SP; solar radiation, SR; surface-water conductivity, SWC, surface-water height, GH; manual surface-water height, WSE; surface-water temperature, WT; wind direction, WD; wind speed, WS; manual discharge, Q. A (#) indicates more than one measurement location.

Focus Area: FA-113 (Oxbow 1)

Station Short Names	Station Primary Purpose	Latitude	Longitude	Data Collection Parameters
ESGFA113-1	Groundwater	62.48947	150.10515	GWL(2), GWT(2), STP, GH(2), WT(2), WSE, Q
ESCFA113-2	Camera	62.49253	150.10396	Cam
ESCFA113-3	Camera	62.48663	150.09798	Cam
ESCFA113-4	Camera	62.48896	150.10530	Cam
ESSFA113-5	Surface Water	62.49643	150.11112	WSE
ESSFA113-6	Surface Water	62.49245	150.11003	WSE
ESSFA113-7	Surface Water	62.48762	150.10106	WSE, Q

Table 7. Groundwater Study primary station purpose, location and data collection parameters for hydrologic stations at PRM 112 (Slough 6).

SuWa Groundwater Study

Focus Area Station Locations

Last Update: 20140922 HFSnyderman

Note: The following are QC3 station coordinates for data collection stations). Specific locations for wells, surface-water pressure transducers, and other sensors are provided in other files.

Data Collection Parameters: air temperature, AT; camera images, Cam; groundwater level, GWL; groundwater temperature, GWT; groundwater conductivity GWC; net radiation, NR, relative humidity, RH; sap flow, SF; soil heat flux, SHF; soil-moisture profile, SMP; soil-temperature profile, SoTP; streambed temperature profile, STP; summer precipitation, SP; solar radiation, SR; surface-water conductivity, SWC, surface-water height, GH; manual surface-water height, WSE; surface-water temperature, WT; wind direction, WD; wind speed, WS; manual discharge, Q. A (#) indicates more than one measurement location.

Focus Area: PRM 112 (Slough 6)

Station Short Names	Station Primary Purpose	Latitude	Longitude	Data Collection Parameters
FSSPRM112-1	Surface Water	62.47251	150.11835	WSE
FSSPRM112-2	Surface Water	62.47065	150.11506	WSE
FSSPRM112-3	Surface Water	62.46607	150.11689	WSE

Table 8. Groundwater Study primary station purpose, location and data collection parameters for hydrologic stations at FA-104 (Whiskers Slough).

SuWa Groundwater Study
Focus Area Station Locations
Last Update: 20140912 HESnyderman

Note: The following are QC3 station coordinates for data collection stations in Focus Areas (FA). Specific locations for wells, surface-water pressure transducers, and other sensors are provided in other files.

Data Collection Parameters: air temperature, AT; camera images, Cam; groundwater level, GWL; groundwater temperature, GWT; groundwater conductivity GWC; net radiation, NR, relative humidity, RH; sap flow, SF; soil heat flux, SHF; soil-moisture profile, SMP; soil-temperature profile, SoTP; streambed temperature profile, STP; summer precipitation, SP; solar radiation, SR; surface-water conductivity, SWC, surface-water height, GH; manual surface-water height, WSE; surface-water temperature, WT; wind direction, WD; wind speed, WS; manual discharge, Q. A (#) indicates more than one measurement location.

Focus Area: FA-104 (Whiskers Slough)

Station Short Names	Station Primary Purpose	Latitude	Longitude	Data Collection Parameters
ESSFA104-1	Surface Water	62.37676	150.16934	AT, GH, WT, STP, Cam
ESMFA104-2	Meteorological	62.37863	150.17190	AT, RH, SMP, SR, SoTP, SHF, GWL, GWT, WD, WS
ESGFA104-3	Groundwater	62.37934	150.17373	GWL, GWT
ESGFA104-4	Groundwater	62.37908	150.17363	GWL, GWT, SF
ESGFA104-5	Groundwater	62.37810	150.17029	GH(2), WT(2), GWL, GWT, WSE, Q
ESGFA104-6	Groundwater	62.37800	150.16912	GWL(2), GWT(2), SF
ESGFA104-7	Groundwater	62.37764	150.16822	GWL, GWT, SF
ESGFA104-8	Groundwater	62.37692	150.16562	GWL, GWT, SF, GH, WT
ESGFA104-9	Groundwater	62.37626	150.17091	GWL(2), GWT(2), GH, WT, STP, SWC, WSE, Q, other
ESGFA104-10	Groundwater	62.38402	150.15125	GWL(2), GWT(2), GH, WT, STP(2)
ESGFA104-11	Groundwater	62.37622	150.16996	GWL, GWT
ESGFA104-12	Groundwater	62.37622	150.16996	GWL, GWT
ESGFA104-13	Groundwater	62.37824	150.17100	GWL, GWT
ESCFA104-16	Camera	62.37457	150.16850	Cam
ESCFA104-17	Camera	62.37676	150.17157	Cam
ESCFA104-18	Camera	62.37943	150.16961	Cam
ESCFA104-19	Camera	62.37986	150.16679	Cam
ESCFA104-20	Camera	62.38351	150.15477	Cam
ESCFA104-21	Camera	62.38388	150.15211	Cam
ESCFA104-22	Camera	62.38180	150.16376	Cam
ESSFA104-23	Surface Water	62.38638	150.15438	WSE, Q
ESSFA104-24	Surface Water	62.37948	150.16329	WSE, Q