Attachment A

Open Water HEC-RAS Flow Routing Model (January 2013)

Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Open Water HEC-RAS Flow Routing Model

Prepared for

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LIST OF ACRONYMS AND SCIENTIFIC LABELS

Abbreviation	Definition
ADCP	Acoustic Doppler Current Profiler
Alluvial	Relating to, composed of, or found in alluvium.
AEA	Alaska Energy Authority
AT	air temperature
Bank	The sloping land bordering a stream channel that forms the usual boundaries of a channel. The bank has a steeper slope than the bottom of the channel and is usually steeper than the land surrounding the channel.
Calibration	In the context of hydrologic modeling, calibration is the process of adjusting input variables to minimize the error between predicted and observed water surface elevations or other hydrologic parameters.
Cfs	cubic feet per second
Channel	A natural or artificial watercourse that continuously or intermittently contains water, with definite bed and banks that confine all but overbank stream flows.
Confluence	The junction of two or more rivers or streams.
COV	coefficient of variation
Cross-section	A plane across a river or stream channel perpendicular to the direction of water flow.
Datum	A geometric plane of known or arbitrary elevation used as a point of reference to determine the elevation, or change of elevation, of another plane (see gage datum).
Depth	Water depth at the measuring point (station).
Devils Canyon	Located at approximately Susitna River Mile (RM) 150-161, Devils Canyon contains four sets of turbulent rapids rated collectively as Class VI. This feature is a partial fish barrier because of high water velocity.
Discharge	The rate of stream flow or the volume of water flowing at a location within a specified time interval.
Drainage area	The total land area draining to any point in a stream. Also called catchment area, watershed, and basin.
El.	Elevation
FERC	Federal Energy Regulatory Commission
Floodplain	1. The area along waterways that is subject to periodic inundation by out-of-bank flows. 2. The area adjoining a water body that becomes inundated during periods of over-bank flooding and that is given rigorous legal definition in regulatory programs. 3. Land beyond a stream channel that forms the perimeter for the maximum probability flood. 4. A relatively flat strip of land bordering a stream that is formed by sediment deposition. 5. A deposit of alluvium that covers a valley flat from lateral erosion of meandering streams and rivers.
Fps	feet per second
Ft	Feet
Gaging station	A specific site on a stream where systematic observations of stream flow or other hydrologic data are obtained.
Geomorphic reach	Level two tier of the habitat classification system. Separates major hydraulic segments into unique reaches based on the channel's geomorphic characteristic.
Geomorphology	The scientific study of landforms and the processes that shape them.

Abbreviation	Definition
GIS	Geographic Information System. An integrated collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes.
GPS	Global Positioning System. A system of radio-emitting and -receiving satellites used for determining positions on the earth.
Gradient	The rate of change of any characteristic, expressed per unit of length (see Slope). May also apply to longitudinal succession of biological communities.
Groundwater (GW)	In the broadest sense, all subsurface water; more commonly that part of the subsurface water in the saturated zone.
HEC-RAS	hydraulic flow-routing model
Hydrograph	A graph showing stage, flow, velocity, or other property of water with respect to time.
Hydraulic model	A computer model of a segment of river used to evaluate stream flow characteristics over a range of flows.
Ice cover	A significant expanse of ice of any form on the surface of a body of water.
Ice-free	No floating ice present.
ILP	Integrated Licensing Process
LiDAR	Light Detection and Ranging. An optical remote sensing technology that can measure the distance to a target; can be used to create a topographic map.
Main channel	For habitat classification system: a single dominant main channel. Also, the primary downstream segment of a river, as contrasted to its tributaries.
Mainstem	Mainstem refers to the primary river corridor, as contrasted to its tributaries. Mainstem habitats include the main channel, split main channels, side channels, tributary mouths, and off-channel habitats.
Manning's equation	V = 1.486 R2/3S1/2/n in English units (V = R2/3S1/2/n in SI units) where V = mean flow velocity, R = hydraulic radius, and S = hydraulic slope; n is a coefficient of roughness.
Mph	miles per hour
N/A	not applicable *or* not available
NAVD	North American Vertical Datum, 1988
NEPA	National Environmental Policy Act
No.	Number
NSRS	National Spatial Reference System
ºC	degrees Celsius
OHW	ordinary high water
Open lead	Elongated opening in the ice cover caused by water current (velocity lead) or warm water (thermal lead).
Period of record	The length of time for which data for an environmental variable has been collected on a regular and continuous basis.
PRM	Project River Mile(s) based on the wetted width centerline of the main channel from 20122 Matanuska-Susitna Borough digital orthophotos. PRM 0.0 is established as mean lower low water of the Susitna River confluence at Cook Inlet.
Project	Susitna-Watana Hydroelectric Project
Q	Hydrological abbreviation for discharge, usually presented as cfs (cubic feet per second) or cms (cubic meters per second). Flow (discharge at a cross-section).

Abbreviation	Definition
QC	quality assurance, quality control
Reservoir	A body of water, either natural or artificial, that is used to manipulate flow or store water for future use.
Riparian	Pertaining to anything connected with or adjacent to the bank of a stream or other body of water.
River mile	River Mile(s) referencing those of the APA Project. These were the distance of a point on a river measured in miles from the river's mouth along the low-water channel.
RTK	Real time kinematic, in reference to a GPS survey method.
S	Second
Side channel	Lateral channel with an axis of flow roughly parallel to the mainstem, which is fed by water from the mainstem; a braid of a river with flow appreciably lower than the main channel. Side channel habitat may exist either in well-defined secondary (overflow) channels, or in poorly-defined watercourses flowing through partially submerged gravel bars and islands along the margins of the mainstem.
Slope	The inclination or gradient from the horizontal of a line or surface.
Slough	A widely used term for wetland environment in a channel or series of shallow lakes where water is stagnant or may flow slowly on a seasonal basis. Also known as a stream distributary or anabranch.
Stage	The distance of the water surface in a river above a known datum.
Stage-discharge relationship	The relation between the water-surface elevation, termed stage (gage height), and the volume of water flowing in a channel per unit time.
Thalweg	A continuous line that defines the deepest channel of a watercourse.
Three Rivers Confluence	The confluence of the Susitna, Chulitna, and Talkeetna rivers at Susitna River Mile (RM) 98.5 represents the downstream end of the Middle River and the upstream end of the Upper River.
Tributary	A stream feeding, joining, or flowing into a larger stream (at any point along its course or into a lake). Synonyms: feeder stream, side stream.
TWG	Technical Workgroup
USACE	U.S. Army Corps of Engineers
USGS	DOI, Geological Survey
Watana Dam	The dam proposed by the Susitna-Watana Hydroelectric project. The approximately 750-foot-high Watana Dam (as measured from sound bedrock) would be located at river mile (RM) 184 on the Susitna River.
Water slope	Change in water surface elevation per unit distance.
Wetted channel width (wetted Perimeter)	The length of the wetted contact between a stream of flowing water and the stream bottom in a plane at right angles to the direction of flow.
WT	water temperature

1. INTRODUCTION AND STUDY GOALS

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). The Project is located on the Susitna River, an approximately 300 mile long river in the Southcentral region of Alaska. The Project's dam site will be located at Project River Mile (PRM) 187.2. The results of this study and of other proposed studies will provide information needed to support the FERC's National Environmental Policy Act (NEPA) analysis for the Project license.

Project operations will likely store water during the snowmelt season (May through August) and release it during the winter (October through April; AEA 2011). This would alter the seasonal hydrology in the Susitna River downstream from the dam. In addition to these seasonal changes, the Project may be operated in a load-following mode. Daily load-following operations will typically release higher volumes of water during peak-load hours, and lower volumes of water during off-peak hours. Flow fluctuations that originate at the powerhouse will travel downstream and attenuate, or dampen, as they travel downstream. The waves created by load following operations will affect the aquatic habitat of the Susitna River downstream from the powerhouse, especially along the margins of the river that are exposed to daily cycles of inundation and dewatering (i.e., the varial zone).

Flow releases from the Project are the result of hydropower rules that specify minimum flow releases needed from a Project powerhouse to meet a power generation requirement and schedule. In addition, flow releases are constrained by assumed flow requirements to protect non-power resources such as fish and aquatic habitats. In an effort to meet multiple resource interests, available resources under existing conditions will be analyzed in comparison to alternative operational scenarios. To analyze the impacts of alternative Project operational scenarios on habitats downstream of the Watana Dam site, an open-water flow routing model will be used to translate the effects of changes in flow associated with Project operations to downstream Susitna River locations.

Steady state flow models are used to estimate flow and water surface elevations in a river system provided that flows are stable or changing relatively slowly. For instance, a steady state model can be used to calculate daily flows at downstream locations or when modeling daily habitat time series as part of an instream flow study. However, if flows are fluctuating on an hourly basis, an unsteady flow model is needed to accurately represent how downstream reaches of a river will respond to upstream flow changes. For instance, determining flow and water surface elevations at downstream locations must take into account the travel speed and attenuation of the downstream wave caused by a hydropower project operating in load-following mode. If a downstream tributary exhibits hourly flow fluctuations as a result of glacial runoff, an unsteady flow routing model is needed to integrate the hourly tributary fluctuations into hourly mainstem flow fluctuations downstream of the tributary confluence.

One-dimensional unsteady flow hydraulic models are commonly used to route flow and stage fluctuations through rivers and reservoirs. Examples of public-domain computer models used to perform these types of processes include FEQ (USGS 1997), FLDWAV (U.S. National Weather Service 1998), UNET (U.S. Army Corps of Engineers 2001), and HEC-RAS (U.S. Army Corps of Engineers 2010a, 2010b, and 2010c). The HEC-RAS model has proven to be very robust under mixed flow conditions (subcritical and supercritical), as will be expected in the Susitna River. The HEC-RAS model also has the capability of automatically varying Manning's "n" with stage through the use of the equivalent roughness option. Another feature of HEC-RAS is the capability of varying Manning's "n" on a seasonal basis. The robust performance and flexibility of HEC-RAS make this model an appropriate choice for routing stage fluctuations downstream from the proposed Project dam under open-water conditions (i.e., summer, ice-free). Information on downstream flow and water surface elevations during winter ice-covered conditions will be developed as part of an Ice Processes Model as described in RSP Section 7.6: Ice Processes in the Susitna River Study. The seasonal timing of the transition from the HEC-RAS model to the Ice Processes Model and vice versa will vary from year-to-year and will depend on seasonal climate conditions.

The foundation of the Instream Flow Study (IFS) analyses rests with the development of the Susitna River Mainstem Flow Routing Models (MFRM) (HEC-RAS, Ice Processes Model) that will provide hourly flow and water surface elevation data at numerous locations longitudinally distributed throughout the length of the river downstream of the proposed dam site. During 2012, the open-water flow routing model extended from the proposed dam site at PRM 187.2 downstream to PRM 80.0 (about 23 miles downstream from the confluence with the Chulitna River). The downstream extent of the open-water flow routing model will be identified by Q2 2013 and revisited in Q1 2014 following collection and analyses of additional data.

The IFS analyses will involve the development of two different flow routing models: the open-water model (HEC-RAS) and a winter model to route flows under ice-covered conditions. As noted, the HEC-RAS routing model has been developed initially based on river cross-sections and on gaging stations on the Susitna River that were established and measured in 2012 as part of the IFS program. A total of 88 cross-sections were surveyed in 2012 (16 between the proposed dam site and Devils Canyon, 59 between Devils Canyon and the Three Rivers Confluence, and 13 downstream from the Three Rivers Confluence). At these cross-sections, a total of 170 pairs of flow and water surface elevations were measured during the course of the 2012 field season.

In addition, a total of 13 gaging stations were established on the Susitna River in 2012. These stations were set up to measure and record stage in real time every 15 minutes. The stations will be maintained in 2013–2014. Data recorded at these stations in 2012 was used to calibrate flow pulse arrival time in the open-water flow routing model, based on measured diurnal glacial melt pulses and rainstorm-generated flood peaks.

The hourly flow records from USGS gaging stations on the Susitna River were also utilized to help develop the HEC-RAS routing model. Depending on the initial results of the flow routing models, it may be necessary to add additional transects to improve the performance of the models between PRM 80.0 and PRM 187.2, and to extend the models downstream of PRM 80.0. Additional transects between PRM 80.0 and PRM 187.2 may be measured in 2013 and 2014 to improve the accuracy for flow and water surface elevation simulations.

Initial results of the initial flow routing model are discussed in this report. As the flow routing model continues to be refined and improved during 2013 and 2014, results from the model will be used to assess the magnitude, timing, and frequency of hourly flow and stage changes associated with proposed load-following operations during ice-free periods. Project operations will likely include storing water during the snowmelt season (May through August) and releasing it during the winter (October through April) (AEA 2011). This would reduce flows downstream of the dam site from May through August and increase flows October through April. Results of the draft open-water flow routing model will also be used to evaluate downstream changes in flow and stage associated with reduced Project flow releases during the open-water portions of the reservoir refill period. Because the results of the Ice Processes Model will not be available prior to the start of the 2013 summer field season, the downstream extent of Project effects on flow and stage during the winter will be assessed by routing winter flow releases identified by the operations model downstream using the open-water flow routing model. Although stage and flow projections during the winter will not be robust, they will provide sufficient information on downstream flow and stage effects to support early 2013 decisions regarding the need to extend resource studies into the Lower River Segment. Should extension of an open-water flow routing model downstream of PRM 80.0 be needed to address data needs of riverine process and habitat modeling studies, the additional channel and hydraulic data can be collected in Q3 2013 and if necessary, Q3 2014.

During the initial development and calibration of the HEC-RAS model, the drainage areas of ungaged tributaries were estimated and used to help estimate accretion flows to the Susitna River between locations where flows are measured. The flow estimates developed for ungaged tributaries will be refined based on flows measured in those tributaries in 2013 and 2014.

The gaging stations initially installed in 2012 will be maintained through 2013 and 2014 to help calibrate and validate the flow routing models and provide data supporting other studies. The gaging stations will be used to monitor stage and flow under summer, ice-free conditions and to monitor water pressure under winter ice-covered conditions. The stations record additional measurements including water temperature and camera images of the river conditions (summer and winter). Continuous measurement of water pressures during the 2012–2013 and the 2013–14 winter periods under ice-covered conditions will produce information different from open-water conditions. During partial ice cover, the pressure levels measured by the pressure transducers are affected by flow velocities, ice-cover roughness characteristics, and other factors such as entrained ice in the water column. The pressure-head data are important for understanding groundwater/surface water interactions.

Periodic winter discharge measurements (January and March) will be completed at selected gaging stations in the winter, in coordination with USGS winter measurement programs, and will provide valuable information for understanding hydraulic conditions in the river during a season when groundwater plays a more prominent role in aquatic habitat functions. Winter flow measurements will also be used to help develop the Ice Processes Model and supporting analyses.

Once developed and calibrated, the HEC-RAS model can be used to provide a time history of flow releases from the dam and to predict the flow and stage history at each of the downstream cross-sections. These predicted flow and stage responses can then be evaluated at multiple levels to assess the impacts to aquatic habitat.

Output from the flow routing models will provide the fundamental input data to a suite of habitat-specific and riverine process-specific models that will be used to describe how the existing flow regime relates to and has influenced various resource elements (e.g., salmonid spawning and rearing habitats and the accessibility to these habitats in the mainstem, side channels, sloughs, and tributary deltas; invertebrate habitat; sediment transport processes; ice dynamics; large woody debris (LWD); the health and composition of the riparian zone). These same models will likewise be used to evaluate resource responses under existing conditions and under alternative Project operational scenarios, again via output from the routing models. As an unsteady flow model, the routing models will be capable of providing flow and water surface elevation information at each location on an hourly basis and therefore Project effects on flow can be evaluated on multiple time steps (hourly, daily, and monthly) as necessary to evaluate different resource elements.

2. PROJECT SETTING

2.1. Study Area

During the 1980s studies, the Susitna River was characterized into three river segments extending above and below the two proposed dam sites. After researching potential Project configurations, AEA is proposing a single dam configuration at the Watana Dam site at PRM 187.2. The proposed study characterizes the Susitna River as three segments (Figure 2.1-1). The Upper River Segment represents that portion of the watershed above the Watana Dam site at PRM 187.2, the Middle River Segment extends from PRM 187.2 downstream to the Three Rivers Confluence at PRM 101, and the Lower River Segment extends from the Three Rivers Confluence to Cook Inlet (Figure 2.1-1). The 2012 study area for these analyses extends from the Watana Dam site at PRM 187.2 on the Susitna River downstream to PRM 80 (about 21 miles downstream from the Three Rivers Confluence).

Although both Middle and Lower River segments are under consideration as part of the Susitna Instream Flow Study (RSP Section 8.5: Fish and Aquatics Instream Flow Study and RSP Section 8.6: Riparian Instream Flow Study), the focus of the 2012 open-water flow routing modeling effort was on the Middle River and a 21 mile long section at the upstream end of the Lower River Segment. The downstream extent of the open-water flow routing model will be identified by Q2 2013 and revisited in Q1 2014 following collection and analyses of additional data.

3. SUMMARY OF EXISTING INFORMATION

3.1. 1980s Information Review

A one-dimensional, steady-state hydraulic model (HEC-2, U.S. Army Corps of Engineers, 1976) was initially developed for the Susitna River in the 1980s by R&M Consultants (1982). Two reaches were modeled: one below Devils Canyon, and the other above Devils Canyon.

The reach below Devils Canyon extended from the confluence with the Chulitna River to the downstream end of Devils Canyon. The reach below Devils Canyon consisted of 66 cross-sections of the Susitna River. These cross-sections were surveyed just prior to and during freeze-up in the fall of 1980.

The reach above Devils Canyon consisted of 23 cross-sections of the Susitna River. This reach extended from the confluence with Devil Creek (about 23 miles downstream from the proposed Watana Dam site) to the confluence with Deadman Creek (about 2 miles upstream from the proposed Watana Dam site). These cross-sections were surveyed in March 1981 by drilling holes through the ice.

Water surface elevations were monitored at eight sites in the reach below Devils Canyon for flows ranging from 9,700 to 52,000 cfs as measured at the Gold Creek gage. Water surface elevations were monitored at four sites in the reach above Devils Canyon for flows ranging from 8,100 to 46,400 cfs as measured at the Watana gage. While water surface elevations were monitored at eight sites downstream from Devils Canyon and four sites above Devils Canyon, concurrent flow measurements were not made at those 12 locations. Flows were estimated at those 12 sites from flows measured at the Watana and Gold Creek gages, with a drainage area correction applied. With these measured water surface elevations and estimated flows, the HEC-2 model was calibrated to simulate water surface elevations that were mostly within plus or minus 0.5 feet of the observed water surface elevations.

The HEC-2 model that was originally developed by R&M Consultants (1982) was then modified by the Harza-EBASCO Susitna Joint Venture (1984). The focus of the work by the Harza-EBASCO Susitna Joint Venture was on the reach below Devils Canyon. The length of this reach was extended downstream to Sunshine Gage, and the total number of cross-sections was increased from 66 to 107. The HEC-2 model developed by the Harza-EBASCO Susitna Joint Venture was then recalibrated to simulate water surface elevations that were mostly within plus or minus 0.5 feet of the observed water surface elevations.

3.2. 2012 HEC-ResSim Model

A HEC-ResSim model (U.S. Army Corps of Engineers, 2007) was developed for the Susitna River downstream from the Watana Dam site using the cross-sections that were surveyed in the 1980s, and the stage discharge rating curves that were developed during the 1980s (MWH 2012). The HEC-ResSim model will route flow fluctuations downstream through a river using hydrologic routing methods. The HEC-ResSim model will account for the downstream propagation and attenuation of flow pulses.

A *hydrologic* unsteady flow routing model, such as HEC-ResSim, can use measured stage hydrographs and stage:discharge relationships at an upstream and downstream location to calibrate how an hourly flow time series at the upstream location translates and dampens at the downstream location. A rough estimate of stage fluctuations can be developed at intermediate locations, but only if a stage:discharge relationship is available for that intermediate location. If hourly flow and stage information are needed at numerous locations, such as the connections between Susitna River side channels and main channel flows, the hydrologic unsteady flow model will require significantly more data than a hydraulic unsteady flow routing model.

In comparison, a *hydraulic* unsteady flow routing model, such as the HEC-RAS model incorporates calculations of the conservation of momentum to directly simulate both flow and stage at downstream locations. A hydraulic routing model can provide reasonably accurate flow and stage information for both steady and unsteady conditions even if a stage-discharge relationship is not available at the locations of interest.

The HEC-ResSim model was used to simulate flow and stage hydrographs downstream from Watana Dam site under Pre-Project and Post-Project conditions during calendar year 1984. This year was selected because USGS Gaging records were available for the entire year in the Susitna

River, as well at the two major tributaries (Chulitna and Talkeetna rivers). In addition, the flows during 1984 are representative of average conditions on both and annual and monthly basis.

The Post-Project condition is referred to herein as the Maximum Load Following Operations Scenario 1 (OS 1). It is based on the assumption that the entire load fluctuation of the entire Railbelt would be provided by the Susitna-Watana Project, and that all other sources of electrical power in the Railbelt would be running at base load. This assumed condition is not realistic for an entire year, and the results of this condition should be conservative with respect to assessing downstream impacts of load following.

3.3. USGS Hydrologic Records

Available stage and flow measurements were obtained from the U.S. Geological Survey (USGS) for the following gaging stations:

- Susitna River above Tsusena Creek, USGS 15291700
- Susitna River at Gold Creek, USGS 15292000
- Chulitna River near Talkeetna, USGS 15292400
- Talkeetna River near Talkeetna, USGS 15292700
- Susitna River at Sunshine, USGS 15292780

Available data from these five gaging stations in 2012 were used to calibrate and validate the flow routing model, while available data from these five gaging stations in 1984 were used to help assess potential downstream effects of the Project for extreme load following conditions.

3.4. Maximum Load Following Operational Scenario 1

Simulated flow releases from the Watana Dam to the Susitna River for the Maximum Load Following Operational Scenario 1 were obtained from MWH for calendar year 1984. These were the same flows that were used in their assessment with the HEC-ResSim model (MWH 2012). As previously discussed this scenario represents an extreme condition that would not occur for an entire year.

4. METHODS

4.1. Field Data Collection

The open water flow routing model relied on field data that were collected in 2012. These data included:

- Cross-sections of the Susitna River surveyed between PRM 80.0 and PRM 187.2
- Flow measurements and concurrent water surface elevation surveys at the river cross-sections
- Stage hydrographs measured at gaging stations established on the Susitna River

Methods for collecting these field data are described in Appendix 1.

4.2. HEC-RAS Model Development and Calibration

The HEC-RAS flow routing model was initially developed from the 88 cross-sections that were surveyed in 2012 on the Susitna River between PRM 80.0 and PRM 187.2 (Figure 2.1-1). For numerical stability under unsteady conditions, additional river cross-sections were interpolated at 1,000-foot intervals. This was especially necessary to route flows through Devils Canyon, a 14-mile long reach of the Susitna River where no cross-sections were surveyed for safety reasons. With the interpolated cross-sections added to the model, the average drop in elevation between cross-sections was about 2 feet.

A longitudinal thalweg profile of the Susitna River was developed from the 88 cross-sections that were surveyed in 2012 (Figure 4.2-1). The channel gradient was steepest through Devils Canyon (0.52%). Downstream from Devils Canyon there was a gradual reduction in channel gradient as would be expected.

4.2.1. Steady-State Model Calibration

The HEC-RAS flow routing model was first calibrated under steady-state conditions using 170 pairs of flow/water surface elevation measurements obtained at the 88 transects in 2012. The relative magnitude of these flow measurements was assessed by using the concurrent flows in the Susitna River at Gold Creek (USGS 15292000) as a common reference point (Figure 4.2-2).

At all of the cross-sections, there was good coverage at the low flow range; however, some transects did not have medium and high flow measurements, especially near the downstream end of the study reach. The cross-sections were measured during three field trips intended to capture high-flow (28,000 cfs), medium-flow (16,000 cfs), and low-flow (8,000 cfs) conditions corresponding to the USGS gage station at Gold Creek (No 15292000). The first two trips were intended to measure medium and high flow conditions during late June-early July and August, but rapidly changing flows made it difficult to predict the timing of target flow conditions. The low-flow trip that began on September 14 was interrupted by a 25-year flood event that required evacuation of the field team on September 20. Work resumed on September 29, but was suspended on October 6 when a second late fall storm resulted in unseasonably high flows. A final attempt commenced on October 15, but abundant river ice and slush pans precluded accurate flow measurements.

The HEC-RAS model was calibrated under steady-state conditions to calculate water surface elevations to within plus or minus 0.2 feet of the observed water surface elevation. The model was calibrated by selecting a reasonable Manning's "n" based on records of field observations and photographs and by adjusting the shape of the interpolated cross-section located downstream from each surveyed cross-section. Energy losses in rivers result from a combination of friction losses (as accounted for with Manning's equation) and expansion/contraction losses (controlled by downstream channel geometry). In the absence of real channel shape information downstream from each surveyed cross-section, the shape of the interpolated cross-section was used as a calibration tool. This method of calibration is especially appropriate for cross-sections that are influenced by a downstream hydraulic control that has not been surveyed.

4.2.2. Unsteady-State Model Calibration

Flow hydrographs measured in 2012 by the U.S. Geological Survey were used to calibrate the flow routing model under unsteady-state conditions. The locations of these gaging stations are shown in Figure 4.2-3. They consisted of the following locations:

- Susitna River above Tsusena Creek, USGS 15291700
- Susitna River at Gold Creek, USGS 15292000
- Chulitna River near Talkeetna, USGS 15292400
- Talkeetna River near Talkeetna, USGS 15292700
- Susitna River at Sunshine, USGS 15292780

Hydrology data for the week of August 11 to 17, 2012 were selected for model calibration. This week was selected because there was a distinct pattern of diurnal flow pulses associated with glacial melt (Figures 4.2-4 and 4.2-5).

By examining the 15 minute flow hydrographs in the Susitna River above Tsusena Creek and at Gold Creek, it was found that the two hydrographs could be synchronized if the flow hydrograph in the Susitna River above Tsusena Creek was shifted forward by 6.4 hours (Figure 4.2-6). The travel time of the pulses over the 47.2 mile-long distance between the two gages is therefore 6.4 hours. The speed of propagation of the pulses, also referred to as the celerity, was estimated to be 7.4 miles per hour (mph) (10.8 feet per second (fps)). The difference in magnitude of flows from Figure 4.2-6 was used to estimate a hydrograph of the ungaged lateral inflow to the Susitna River between Tsusena Creek and Gold Creek.

A similar process was used to estimate hydrographs of ungaged lateral inflow to the Susitna River between Gold Creek and Sunshine. However, the process was complicated by the diurnal fluctuations observed in the Susitna River at Sunshine being influenced by the fluctuations observed in the Susitna River at Gold Creek, the Chulitna River, and the Talkeetna River.

The celerity was assumed to be roughly proportional to the square root of the channel slope, consistent with Manning’s equation. From the celerity measured upstream (7.4 mph), and the channel slopes shown in Figure 4.2-1, the following travel times were estimated:

- 9.75 hr – Susitna River from Gold Creek to Sunshine
- 3.00 hr – Susitna River from the confluence with the Chulitna River to Sunshine
- 2.75 hr – Susitna River from the confluence with the Talkeetna River to Sunshine

In addition the USGS gage on the Chulitna River is several miles upstream from the confluence with the Susitna River. A travel time of 3 hr was assumed between the USGS gage on the Chulitna River and the confluence with the Susitna River.

Using these travel times, the flow hydrographs in the Susitna River at Gold Creek, the Chulitna River, and the Talkeetna River were shifted forward and summed up. The difference between the flow hydrograph at Sunshine gage, and the sum of the three upstream gages was used to estimate the total ungaged lateral accretion to the Susitna River between Gold Creek and Sunshine.

The total ungaged lateral accretion flow to the Susitna River between Gold Creek was then distributed to the following three reaches in proportion to the length of the Susitna River in each reach:

- 37.7 miles – distance along Susitna River between Gold Creek and the confluence with the Chulitna River
- 2.2 miles – distance along the Susitna River between the confluence with the Chulitna River and the confluence with the Talkeetna River
- 12.3 miles – distance along the Susitna River between the confluence with the Talkeetna River and Sunshine

The resultant flow hydrographs for the ungaged lateral inflow to the Susitna River are shown in Figure 4.2-7.

The goal of calibration under unsteady-state conditions was to match the arrival time of pulses from upstream sources in the Susitna River at Gold Creek and also at Sunshine. If it was necessary to accelerate the arrival time of pulses from upstream sources, then interpolated cross-sections that were not used for steady-state calibration were made narrower to increase the celerity. If it was necessary to decelerate the arrival time of pulses from upstream sources, then interpolated cross-sections that were not used for steady-state calibration were made wider to decrease the celerity.

The celerity that was derived from the August 2012 diurnal pulses in the Susitna River between Watana Dam site and Gold Creek gage was used to help select a computational time step in the open water flow routing model. For numerical stability and accurate results, the computational time step should be less than the distance between river cross-sections divided by the celerity. With the surveyed and interpolated cross-sections combined, the distance between cross-sections is about 1,000 feet. This distance divided by the celerity (10.8 fps) yields a time increment of 93 seconds. Thus, a computational time step of one minute (60 seconds) was adopted for the open water flow routing model.

4.3. Model Validation

The flow routing model, calibrated under steady- and unsteady- state conditions, was then validated using the available hydrologic data set for the June 4 through October 14, 2012 period. Input to the model was based on the flow hydrographs illustrated in Figures 4.3-1, 4.3-2, and 4.3-3. Validation consisted of comparing simulated versus measured hydrographs in the Susitna River at Gold Creek and Sunshine. Flows observed in 2012 covered a wide range including the flood that occurred in September when peak flows of about 200,000 cfs were observed in the Susitna River at Sunshine Gage (Figure 4.3-1).

4.4. Assessment of Potential Downstream Stage Changes

Potential downstream changes in flow and water surface elevations were assessed by comparing Pre-Project conditions with the Maximum Load Following OS-1 conditions for calendar year 1984. As previously mentioned, the Maximum Load Following OS-1 conditions represents an extreme condition that would not likely occur for an entire year. Calendar year 1984 was selected because historical gage records were available from the USGS, and because 1984 represents an average hydrological condition on both annual and monthly basis.

The two scenarios (i.e., Pre-Project and OS-1) represent different flow hydrograph releases from Watana Dam and were used as input to the flow routing model (Figure 4.4-1). With the Maximum Load Following OS-1, higher flows would generally be released during winter, and lower flows would be released during the spring and summer until the reservoir fills to capacity. During periods when the reservoir is not full, flow releases with Maximum Load Following OS-1 would exhibit daily and weekly flow fluctuations in response to power generation requirements.

Daily flow records were available from the U.S. Geological Survey for the following locations in 1984:

- Susitna River above Tsusena Creek, USGS 15291700
- Susitna River at Gold Creek, USGS 15292000
- Chulitna River near Talkeetna, USGS 15292400
- Talkeetna River near Talkeetna, USGS 15292700
- Susitna River at Sunshine, USGS 15292780

These daily flows were converted to 15-minute flows in a manner as illustrated in Figure 4.4-2. With the 15-minute flow hydrograph, the daily average was preserved each day, and the 15-minute flow hydrograph was smooth and continuous. No attempt was made during these Version 1 open-water flow routing model runs to account for diurnal glacial melt fluctuations. The 15-minute flow hydrographs, thus derived, are illustrated in Figures 4.4-3, 4.4-4, and 4.4-5.

4.5. Deviations from Scope of Work

There were no significant deviations from Revised Study Plan (AEA 2012) related to development of the Open-water Flow Routing Model. The only exceptions were the number of paired flow/water surface elevations and the tributary drainage area delineations. While there was good low flow coverage in the Middle River and the upper portion of the Lower River segments, some discharge and water level data pairs were not measured at medium and higher flows in 2012, especially in the Lower River below the Three Rivers confluence. As described in Appendix 1, establishing a GPS static control network for the Project and measuring multiple mainstem river channels presented challenging data collection procedures; in addition, flow conditions in 2012 included a 25-year flood event in September which affected the data collection schedule. Drainage areas of tributaries downstream from Watana Dam will be refined in 2013.

5. RESULTS

5.1. Field Data Collection

Version 1 of the open water flow routing model is based on field data that were collected in 2012. Results of the 2012 field data collection activities are discussed in Appendix 1. The open water flow routing model will be updated with field data collected in 2013 (Version 2), and additional field data collected in 2014 (Version 3).

5.2. HEC-RAS Model Development and Calibration

5.2.1. Steady-State Model Calibration

The HEC-RAS model was calibrated under steady-state conditions to calculate water surface elevations to within plus or minus 0.2 feet of the observed water surface elevation. Almost all of the calculated water surface elevations fell within this target range. However, there were a few that were slightly outside of this range.

A summary of the Manning's "n" coefficients that were used for model calibration is presented in Figure 5.2-1. The Manning's "n" coefficients ranged from 0.030 to 0.045. These values are within the range of values determined in the 1980s studies, and are reasonable values for a river as large as the Susitna River. There was a gradual trend of decreasing roughness from upstream to downstream as would normally be expected.

5.2.2. Unsteady-State Model Calibration

For the unsteady-state calibration period from August 11 to August 17, 2012, initial results predicted that the diurnal pulses would arrive late in the Susitna River at Gold Creek (USGS 15292000). To accelerate the arrival of the pulses, the interpolated cross-sections in Devils Canyon were made narrower. After this adjustment, there was good agreement between measured and simulated hydrographs in the Susitna River at Gold Creek (Figure 5.2-2).

A comparison of measured and simulated hydrographs in the Susitna River at Sunshine (USGS 15292780) is shown in Figure 5.2-3). Collecting additional hydrologic data in 2013 and modeling refinements in Q4 2013 will further improve model calibration.

5.3. Model Validation

The calibrated model was then used to analyze the period from June 4 to October 14, 2012. A comparison of measured and simulated hydrographs for this validation period is shown in Figure 5.3-1 for the Susitna River at Gold Creek (USGS 15292000) and in Figure 5.3-2 for the Susitna River at Sunshine (USGS 15292780). Good agreement was found between measured and simulated hydrographs at both locations over a wide range of flow conditions.

5.4. Assessment of Potential Downstream Stage Changes

The calibrated model was then used to assess downstream stage changes associated with Pre-Project and Maximum Load Following OS-1 scenarios for calendar year 1984. Predicted stage hydrographs are shown for the entire year in the Susitna River just below Watana Dam site in Figure 5.4-1. The river at this location is expected to remain ice-free during the winter for the Maximum Load Following OS-1 scenario (RSP Section 7.6: Ice Processes, Section 7.6.2.1). These results suggest an increase in daily average water level of up to 3 to 4 feet in the winter, and a reduction of daily average water level of as much as 6 to 7 feet in the summer when high pre-project flow occurs. It is difficult to discern hourly fluctuations in water level from Figure 5.4-1. Hourly flow and stage fluctuations will be addressed later in this section.

Predicted flow and stage hydrographs are shown for the entire year in the Susitna River at Gold Creek (USGS 15292000) in Figures 5.4-2 and 5.4-3, respectively. Actual results may differ from those depicted in these figures as a result of ice formation in the Middle River downstream of Devils Canyon. These results suggest an increase in daily average water level of up to 2 to 3 feet in the winter, and a reduction of daily average water level of as much as 5 feet in the summer. The data also indicate less daily average flow variability for Maximum Load Following OS-1.

Predicted flow and stage hydrographs are shown for the entire year in the Susitna River at Sunshine (USGS 15292780) in Figures 5.4-4 and 5.4-5, respectively. Actual results may differ from those depicted in these figures as a result of ice formation in the river. These results suggest an increase in daily average water level of up to 1 to 2 feet in the winter, and a reduction of daily average water level of as much as 3 feet in the summer. On average, the daily average water stage change reduction is 1 to 2 feet.

Predicted flow and stage hydrographs are shown for the week of July 23 to July 29, 2012 in the Susitna River below Watana Dam site in Figures 5.4-6 and 5.4-7, respectively. Pre-Project conditions simulated at the various gaging locations do not account for potential diurnal fluctuations associated with summer-time glacial melt. Hourly stage fluctuations within each day associated with Maximum Load Following OS-1 may range from 1.2 to 1.6 feet.

Predicted flow and stage hydrographs are shown for the week of July 23 to July 29, 2012 in the Susitna River at Gold Creek (USGS 15292000) in Figures 5.4-8 and 5.4-9, respectively. Hourly stage fluctuations within each day associated with Maximum Load Following OS-1 may range from 0.7 to 1.0 feet.

Predicted flow and stage hydrographs are shown for the week of July 23 to July 29, 2012 in the Susitna River at Sunshine (USGS 15292000) in Figures 5.4-10 and 5.4-11, respectively. Hourly stage fluctuations within each day associated with Maximum Load Following OS-1 may range from 0.2 to 0.4 feet.

The USGS gage in the Susitna River at Sunshine (USGS 1529780) is located near a highway bridge, as shown in Figure 5.4-12. The Susitna River is a single confined channel in the vicinity of the gage. While this narrow, stable channel serves as a good location for a USGS flow gaging purposes, it is not representative of the overall morphology of the Susitna River below the Three Rivers Confluence.

A wider channel location was measured at PRM 87.1 where the river splits into two channels around an island (Figure 5.4-12). The river at this location is about twice as wide as the wetted channel at the USGS gage, but bank to bank width at PRM 87.1 is not as wide as much of the mainstem river channel in the Lower River Segment. The predicted stage hydrograph at this location is shown for the week of July 23 to July 29, 2012 in Figure 5.4-13. A comparison of stage changes at the USGS gage at Sunshine (PRM 87.9) and the wider transect at PRM 87.1 under Pre-Project conditions and scenario OS-1 indicate the wider transect at PRM 87.1 results in approximately 12 to 19 percent less stage change in response to flow fluctuations than observed at the narrow Sunshine gage location. During flows of 6,000 to about 10,000 cfs, there is little difference between the two locations because the flow is concentrated in the bottom of the channels. As flows increase and inundate the river margins, the influence of a wider channel becomes more apparent and stage changes observed at narrow channel locations such as the Sunshine gage are less representative of overall channel conditions in the river segment.

Predicted flow and stage hydrographs are shown for the week of January 8 to January 14, 2012 in the Susitna River below Watana Dam site in Figures 5.4-14 and 5.4-15, respectively. This portion of the Susitna River is expected to remain ice-free under Maximum Load Following OS-1 conditions. Hourly stage fluctuations within each day associated with Maximum Load Following OS-1 may range from 1.0 to 1.6 feet.

Predicted flow and stage hydrographs are shown for the week of January 8 to January 14, 2012 in the Susitna River at Gold Creek (USGS 15292000) in Figures 5.4-16 and 5.4-17, respectively. Actual results may differ from those depicted in these figures as a result of ice formation in the river. Hourly stage fluctuations within each day associated with Maximum Load Following OS-1 may range from 1.3 to 1.5 feet.

Predicted flow and stage hydrographs are shown for the week of July 23 to July 29, 2012 in the Susitna River at Sunshine (USGS 15292000) in Figures 5.4-18 and 5.4-19, respectively. Actual results may differ from those depicted in these figures as a result of ice formation in the river. Hourly stage fluctuations within each day associated with Maximum Load Following OS-1 may range from 0.6 to 0.8 feet.

The predicted stage hydrograph at PRM 87.1 is shown for the week of January 8 to January 14, 2012 in Figure 5.4-20. Actual results may differ from those depicted in this figure as a result of ice formation in the river. Hourly stage fluctuations within each day associated with Maximum Load Following OS-1 may range from 0.6 to 0.8 feet, similar in magnitude to the stage fluctuations in the Susitna River at Sunshine (USGS 15292780).

To help illustrate the differences between Pre-Project and Maximum Load Following OS-1 conditions at Susitna River cross-section PRM 87.1, Figure 5.4-21 was prepared. This figure shows the shape of the cross-section at PRM 87.1, and water surface elevations associated with Pre-Project and Maximum Load Following OS-1 conditions on January 10, 1984 and July 29, 1984. The thickness of each water surface elevation line was scaled to represent the range between minimum and maximum water surface elevation each day.

6. FUTURE IMPROVEMENTS TO THE MODEL

The flow routing model described in this technical memo represents Version 1. The model in its present form is adequate to provide information to support decisions on the downstream extent of Project effects, help schedule field studies targeting specific flow and stage conditions, and identify 2013 data needs to improve model accuracy. This model will continue to be refined and improved based on field data collected in 2013 and 2014. As described in RSP Table 8.5-14, this initial draft of the open-water flow routing model is being distributed for review in Q1 2013. Additional data needs will be identified in Q2 2013 and field data collected in 2013. Hydrologic data that may be collected in 2013 include additional transect cross-sectional profiles, additional discharge/water level data pairs, and hourly stage data from main channel and tributary locations. A refined version of the open-water flow routing model will be developed in Q4 2013 incorporating available additional data. Hydrologic data will continue to be collected in 2014 and a final open-water flow routing model developed and distributed for review in Q4 2014. Major changes in the mainstem open-water flow routing model results are not anticipated as a result of the additional data collected in 2013 and 2014. However, the additional data and model refinements will improve the accuracy of hourly flow and stage simulations at complex channel features and within instream flow sampling and modeling areas.

Version 2 of this model to be developed and distributed for review in Q4 2013 will incorporate the following additional information:

- Tributary drainage areas will be delineated, and tributary flow measurements will be made. These will be used to help estimate lateral accretion flows.
- Cross-sections will be extended up to higher elevations using LiDAR data and ground-based RTK-GPS surveys.
- Additional pairs of flow/water surface elevations will be made, especially in the Lower Susitna River. These data will be used to help improve the steady-state calibration.
- The model will incorporate additional cross-sections if available through implementation of the geomorphology study (RSP Section 6.6).
- Diurnal glacial melt fluctuations will be incorporated into the summer hydrographs.

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8. TABLES

No tables are included in this report.

9. FIGURES

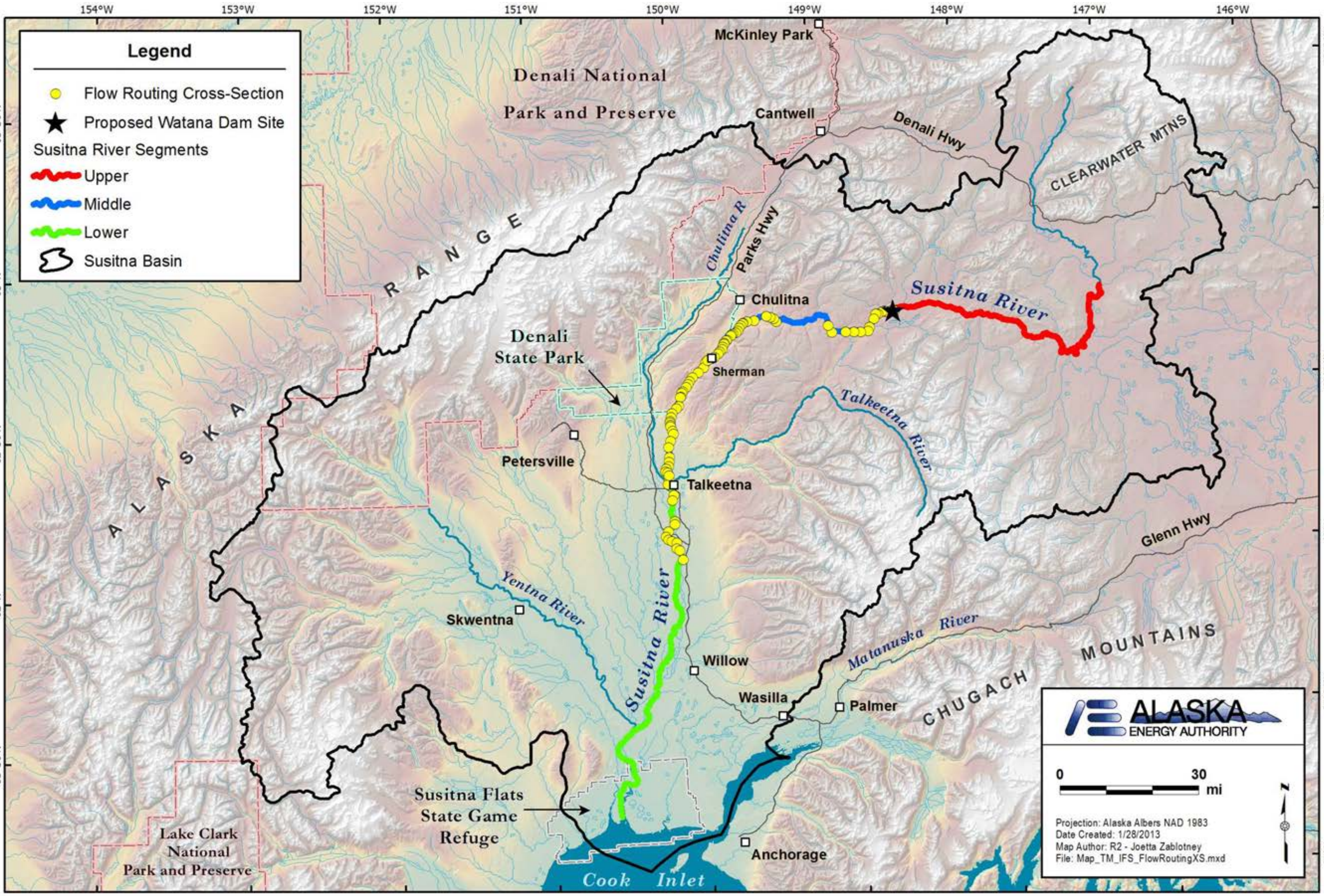


Figure 2.1-1. Map depicting the Upper, Middle and Lower Segments of the Susitna River potentially influenced by the Susitna-Watana Hydroelectric Project, and the locations of 88 cross-sections of the Susitna River surveyed in 2012.

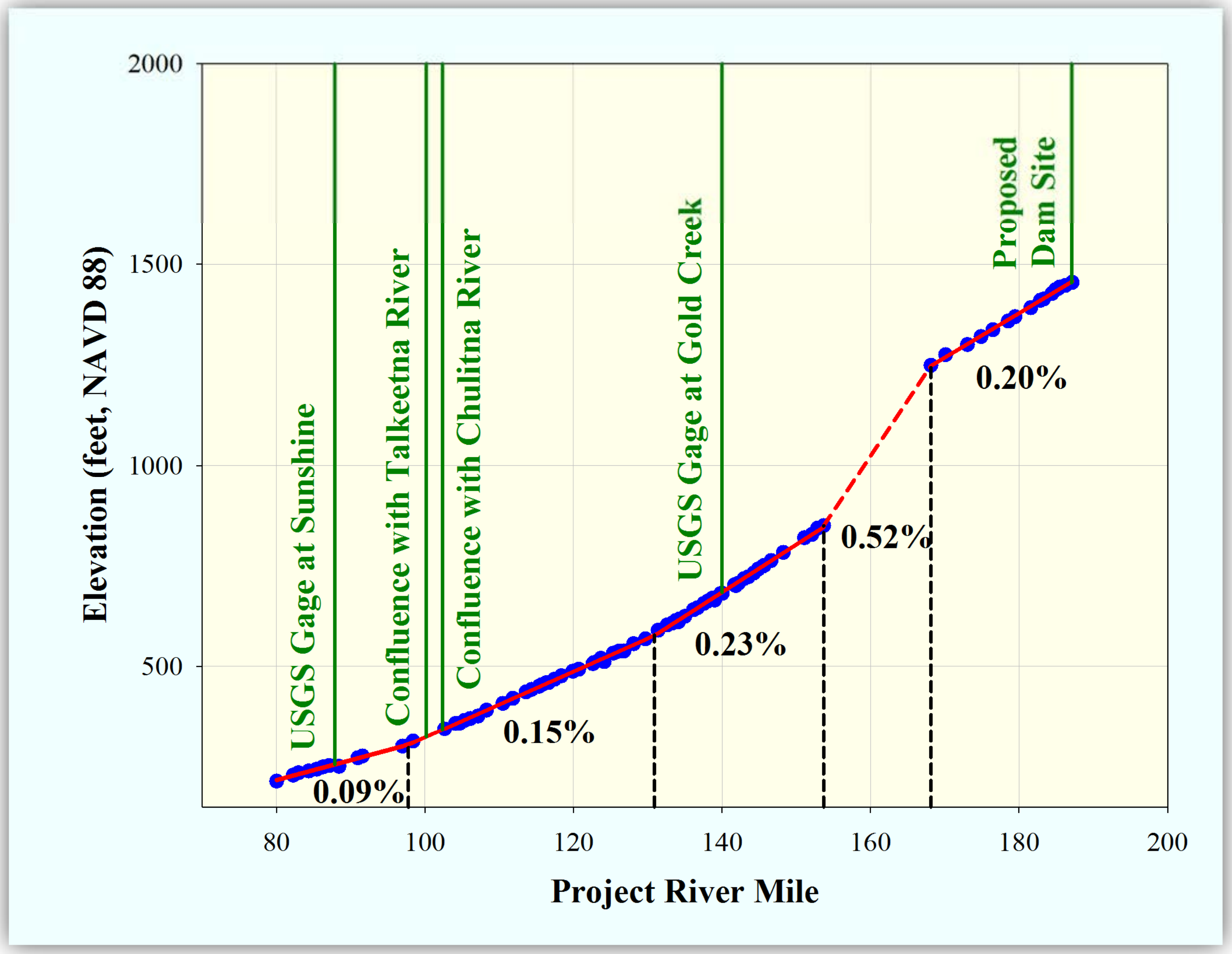


Figure 4.2-1. Longitudinal thalweg profile of the Susitna River extending from PRM 80.0 to PRM 187.2 (Devils Canyon is represented by the dashed red line.

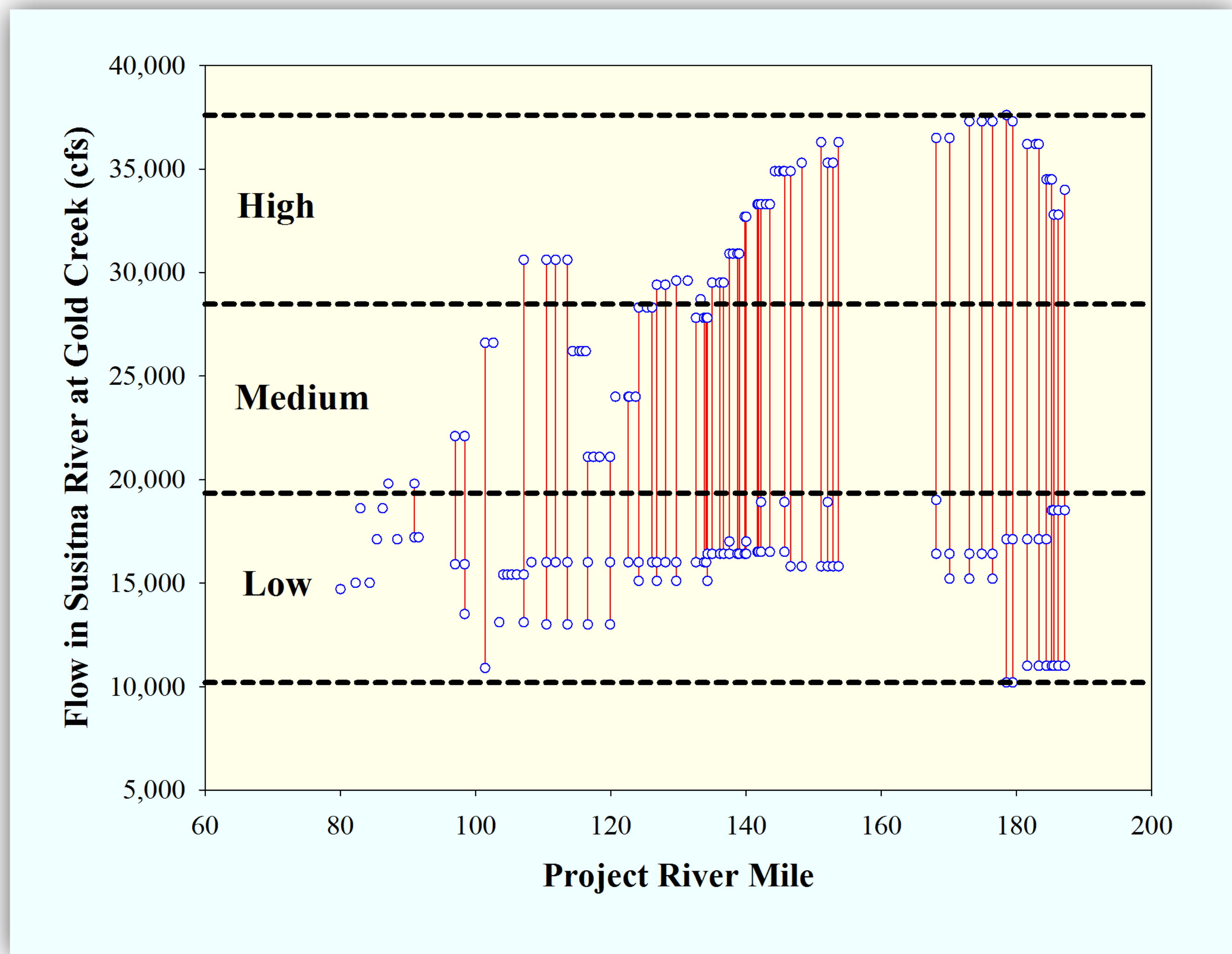


Figure 4.2-2. Locations of flow measurements in the Susitna River in 2012, and classification of flows as low, medium, or high based on concurrent measurements in the Susitna River at Gold Creek (USGS 15292000).

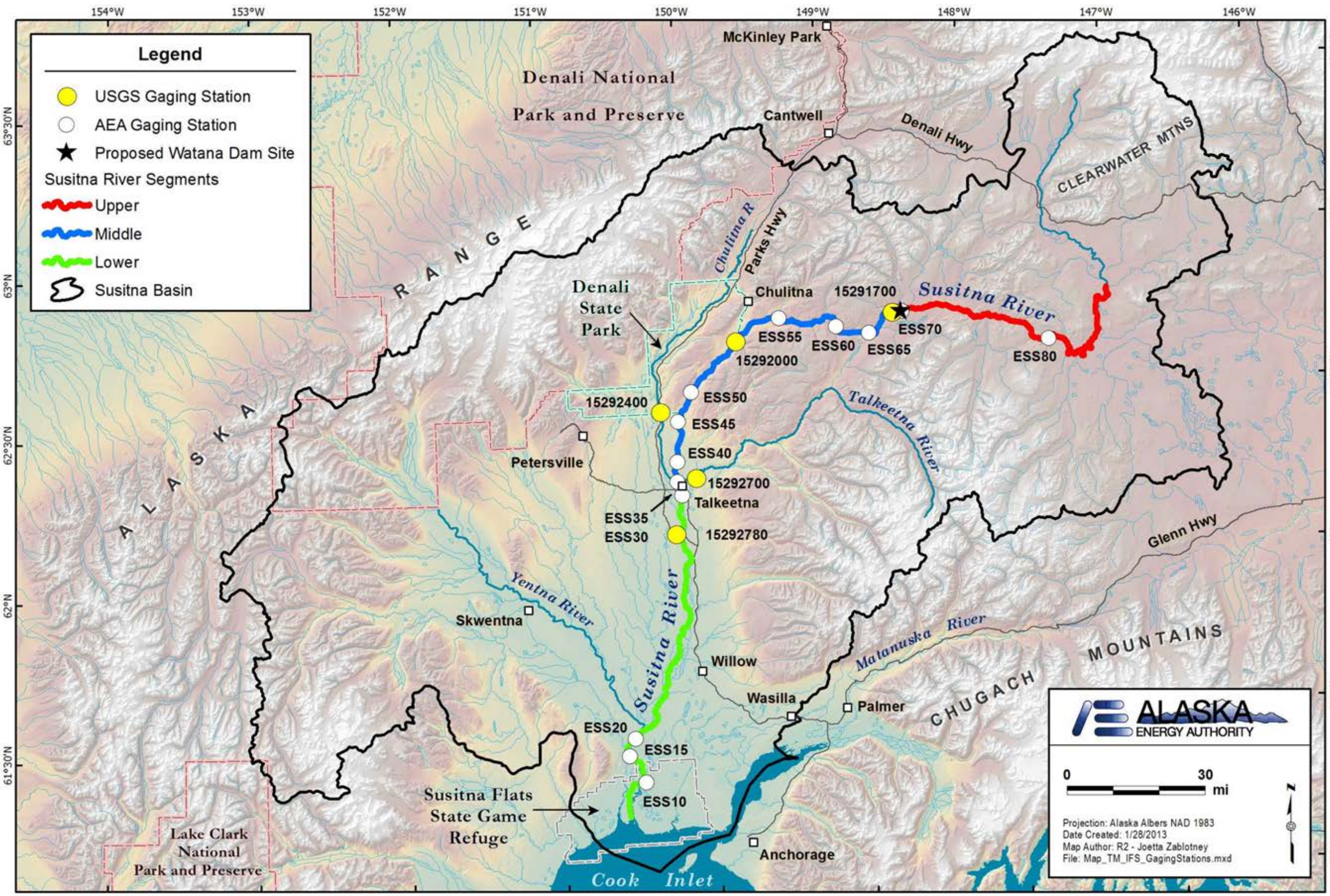


Figure 4.2-3. Locations of USGS gages on the Susitna River, and its tributaries, used for calibration of the flow routing model.

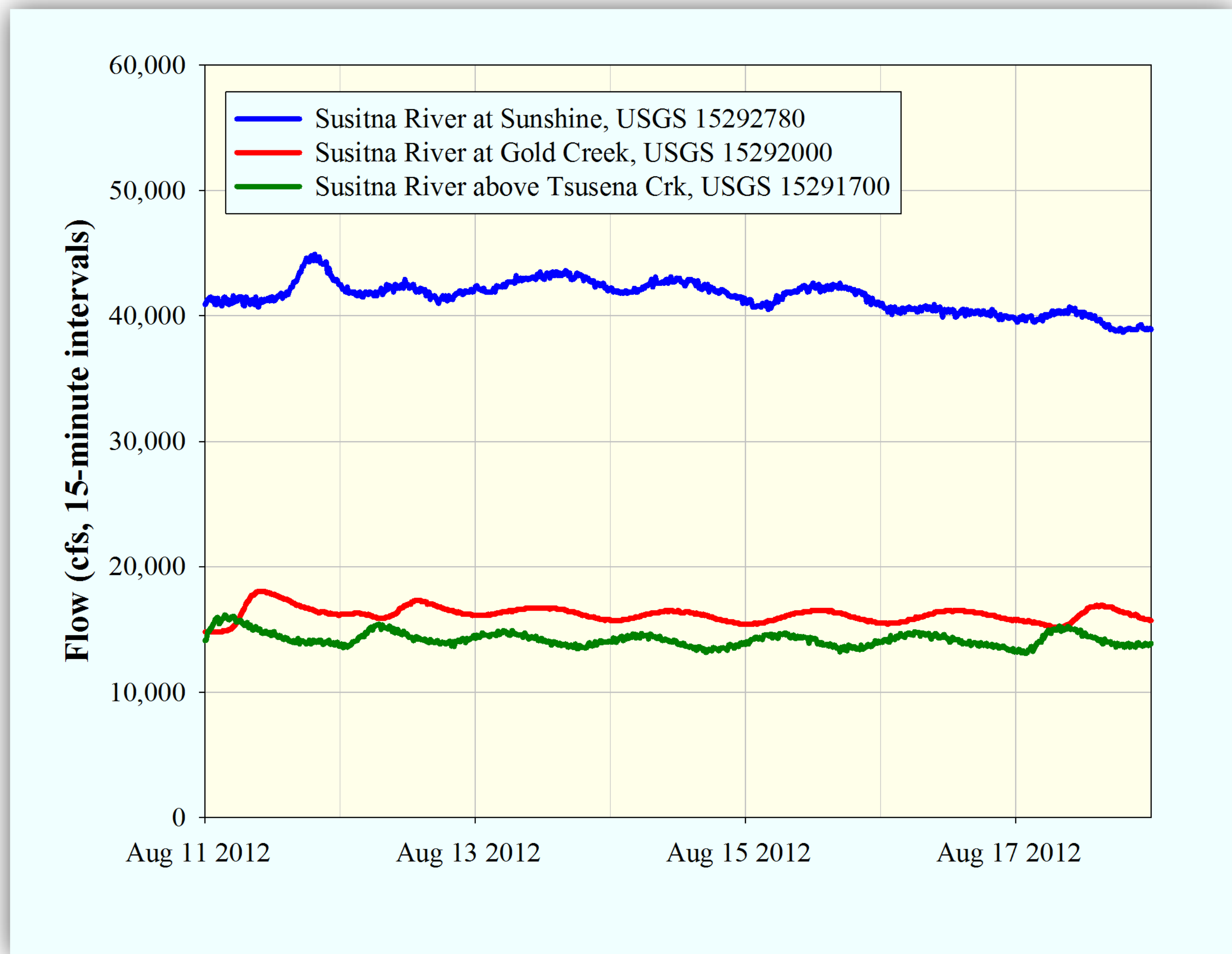


Figure 4.2-4. Flow hydrographs measured at 15-minute intervals by the U.S. Geological Survey in the Susitna River at Sunshine (Gage 15292780), at Gold Creek (Gage 15292000), and above Tsusena Creek (USGS 15291700) during the week of August 11 to 17, 2012 when there were diurnal pulses associated with glacial melt.

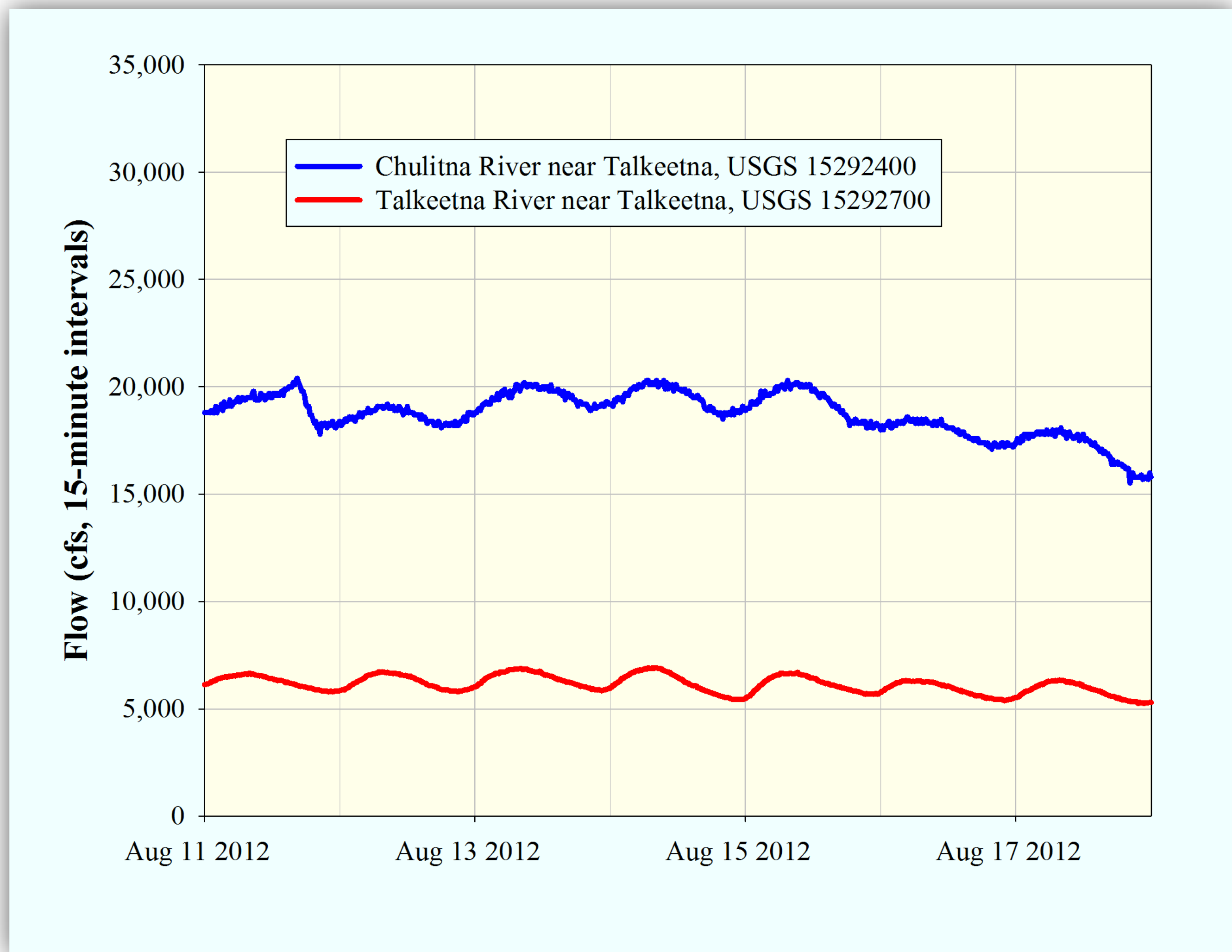


Figure 4.2-5. Flow hydrographs measured at 15-minute intervals by the U.S. Geological Survey in the Chulitna River near Talkeetna (Gage 15292400) and in the Talkeetna River near Talkeetna (USGS 15292700) during the week of August 11 to 17, 2012 when there were diurnal pulses associated with glacial melt.

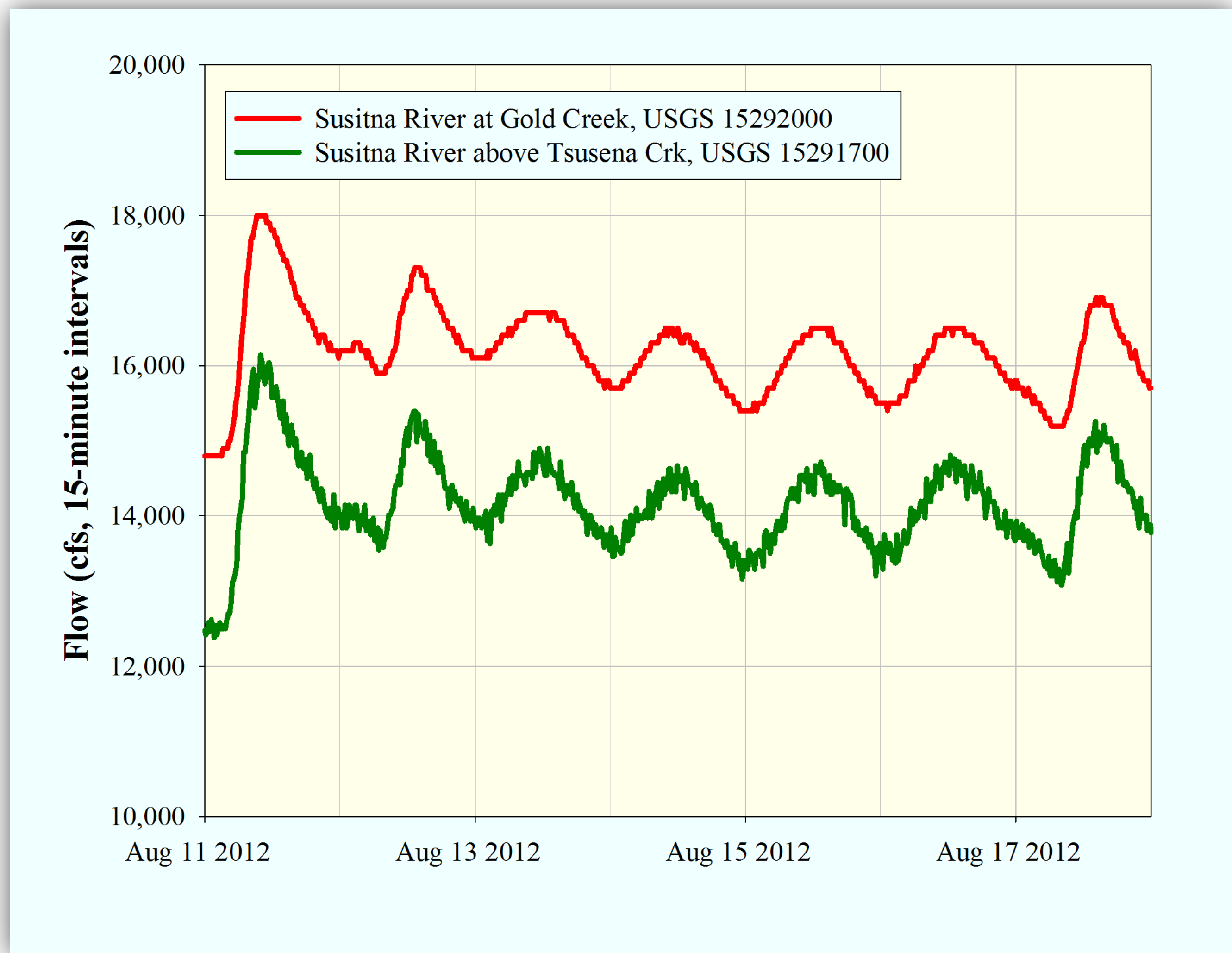


Figure 4.2-6. Flow hydrographs measured at 15-minute intervals by the U.S. Geological Survey in the Susitna River at Gold Creek (Gage 15292000) and above Tsusena Creek (USGS 15291700, shifted forward by 6.4 hours) during the week of August 11 to 17, 2012.

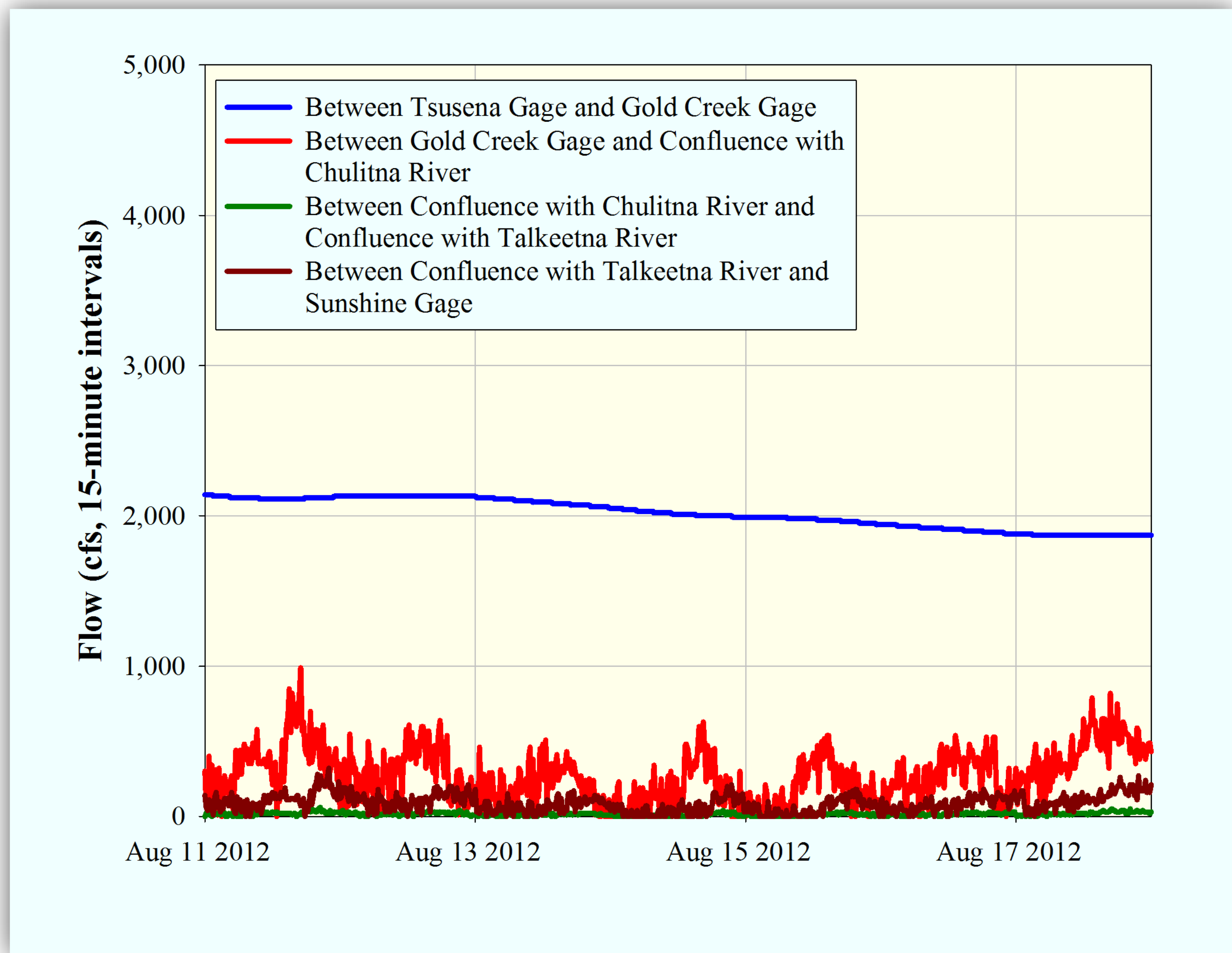


Figure 4.2-7. Ungaged lateral inflow hydrographs at 15-minute intervals to the Susitna River to four reaches between Tsusena Gage and Sunshine Gage, August 11 to 17, 2012.

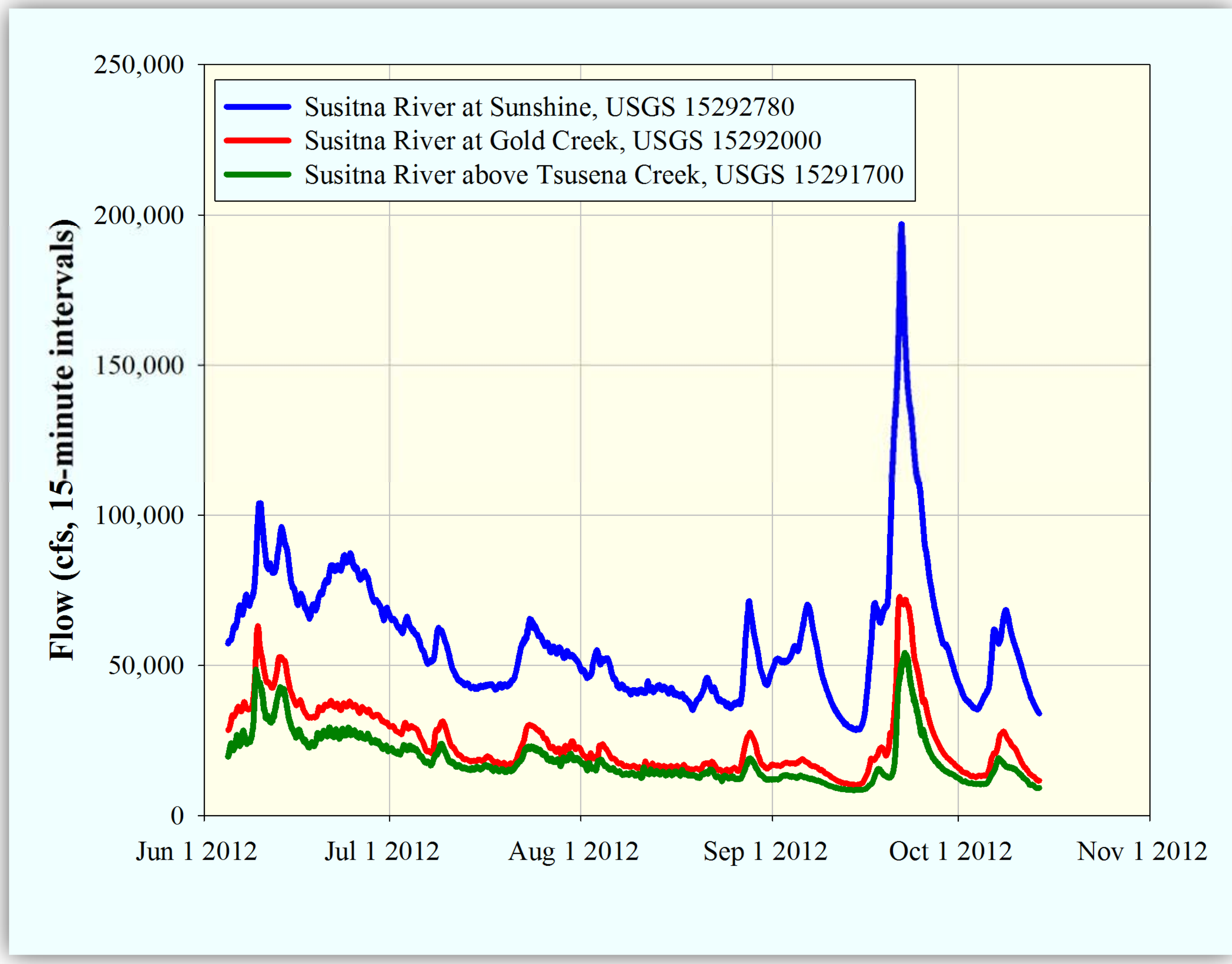


Figure 4.3-1. Flow hydrographs measured at 15-minute intervals by the U.S. Geological Survey in the Susitna River at Sunshine (Gage 15292780), at Gold Creek (Gage 15292000), and above Tsusena Creek (USGS 15291700) during the period from June 4 to October 14, 2012.

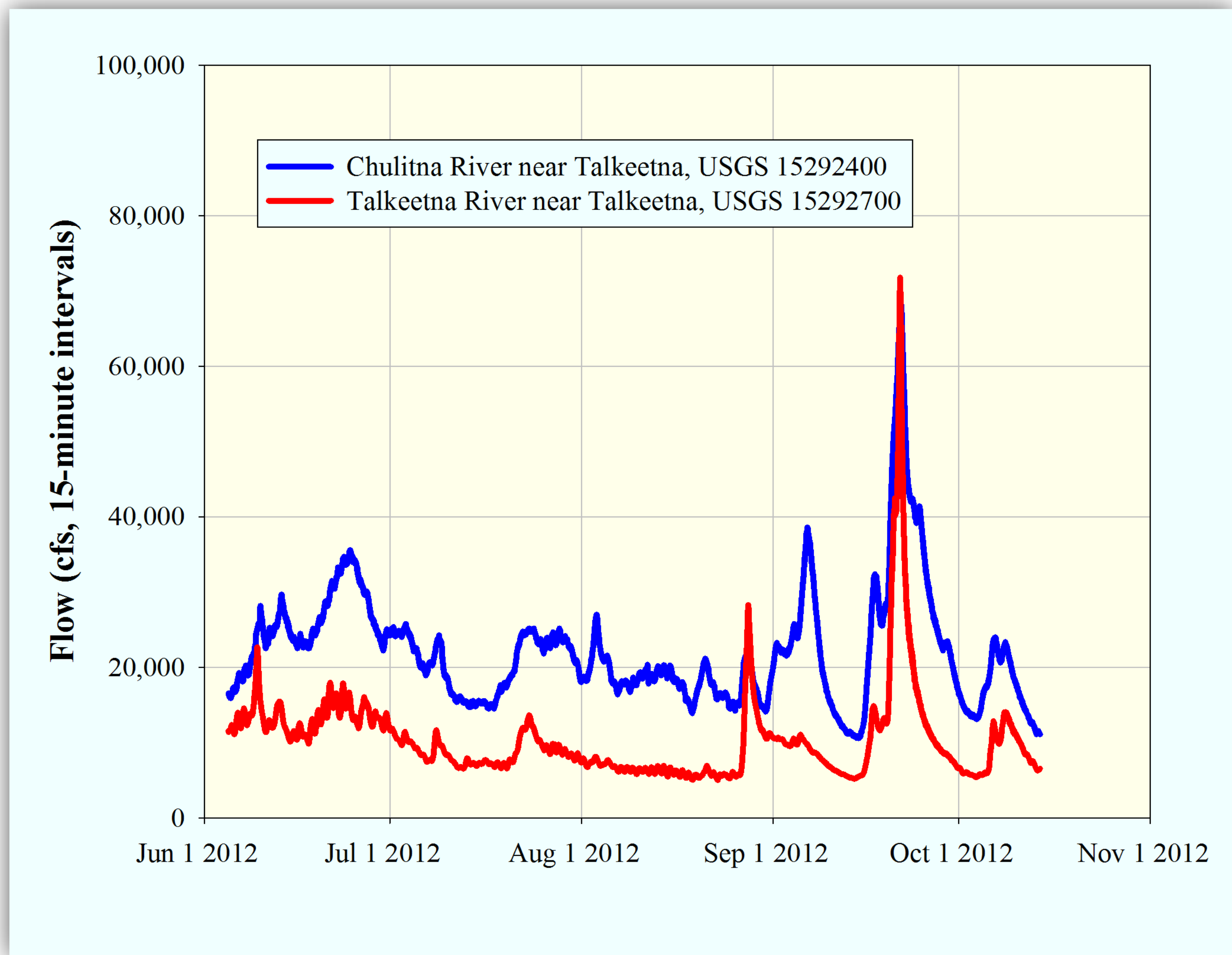


Figure 4.3-2. Flow hydrographs measured at 15-minute intervals by the U.S. Geological Survey in the Chulitna River near Talkeetna (Gage 15292400) and in the Talkeetna River near Talkeetna (USGS 15292700) during the period from June 4 to October 14, 2012.

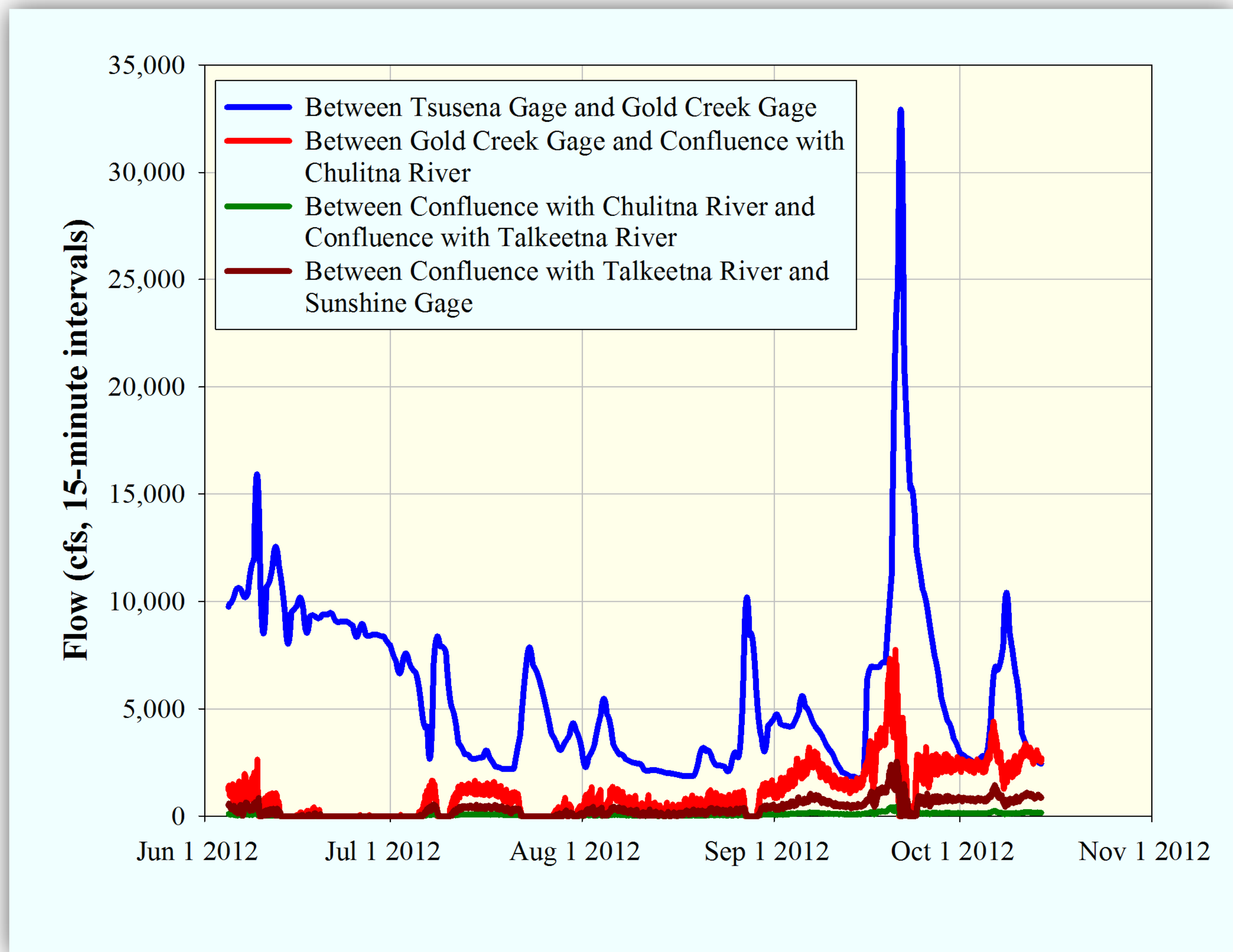


Figure 4.3-3. Ungaged lateral inflow hydrographs at 15-minute intervals to the Susitna River to four reaches between Tsusena Gage and Sunshine Gage during the period from June 4 to October 14, 2012.

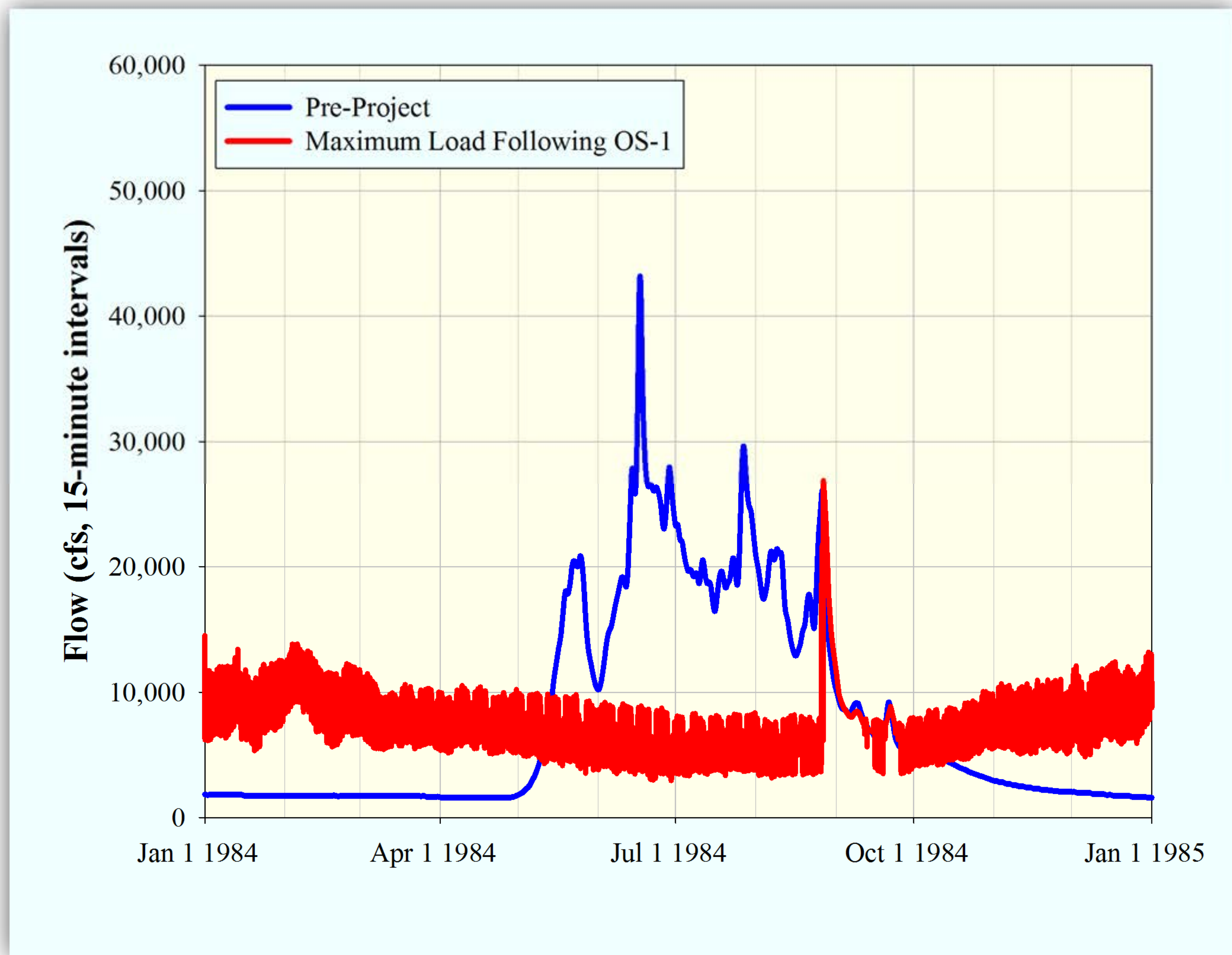


Figure 4.4-1. Flow releases from Watana Dam site, input to the flow routing model for the Pre-Project and Maximum Load Following OS-1 scenarios during calendar year 1984.

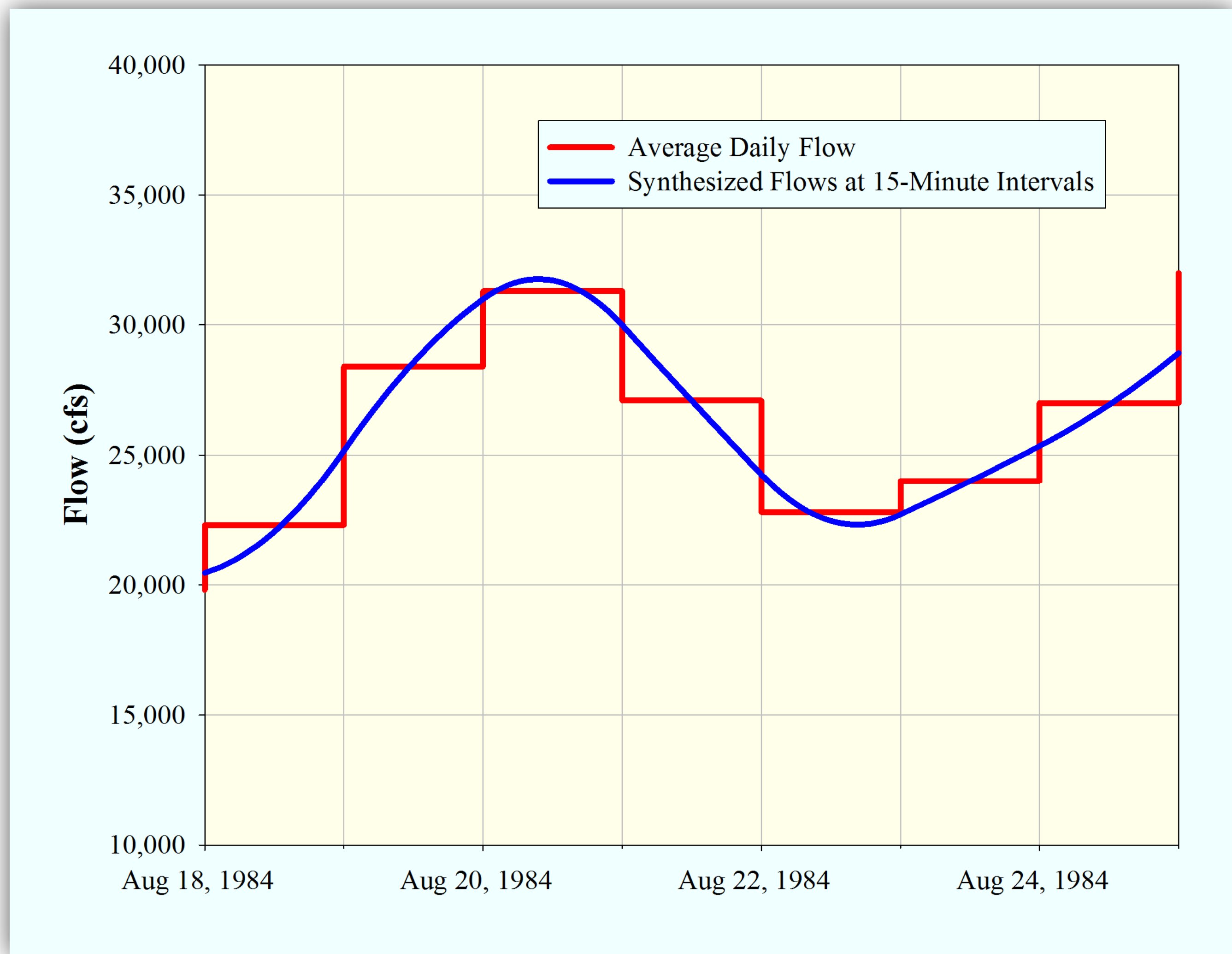


Figure 4.4-2. Illustration of 15-minute flow hydrograph, synthesized from available daily flows. The synthesized 15-minute flow hydrograph does not account for potential diurnal variation associated with glacial melt.

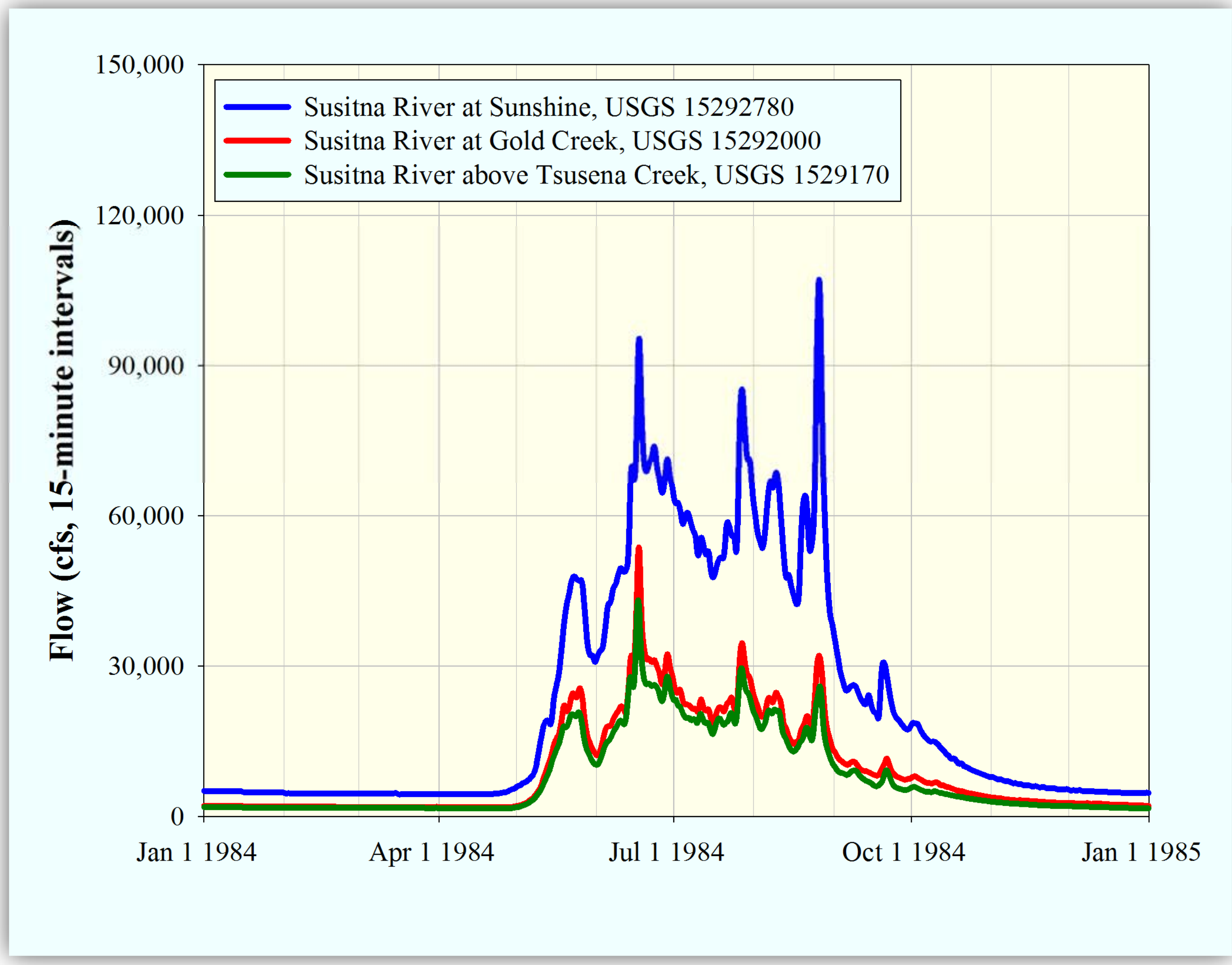


Figure 4.4-3. Flow hydrographs synthesized at 15-minute intervals from daily flows reported by the U.S. Geological Survey in the Susitna River at Sunshine (Gage 15292780), at Gold Creek (Gage 15292000), and above Tsusena Creek (USGS 15291700) during calendar year 1984.

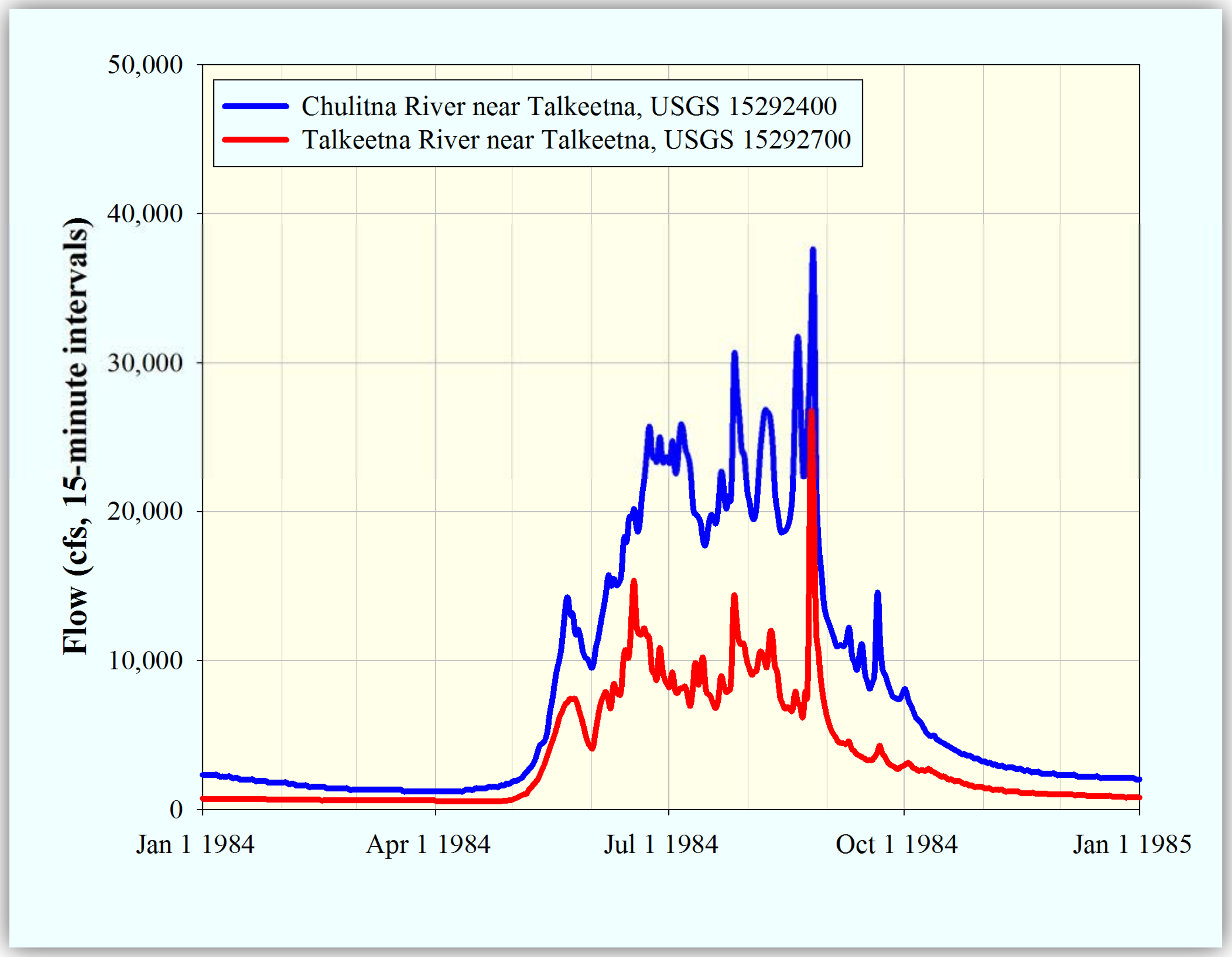


Figure 4.4-4. Flow hydrographs synthesized at 15-minute intervals from daily flows reported by the U.S. Geological Survey in the Chulitna River near Talkeetna (Gage 15292400) and in the Talkeetna River near Talkeetna (USGS 15292700) during calendar year 1984.

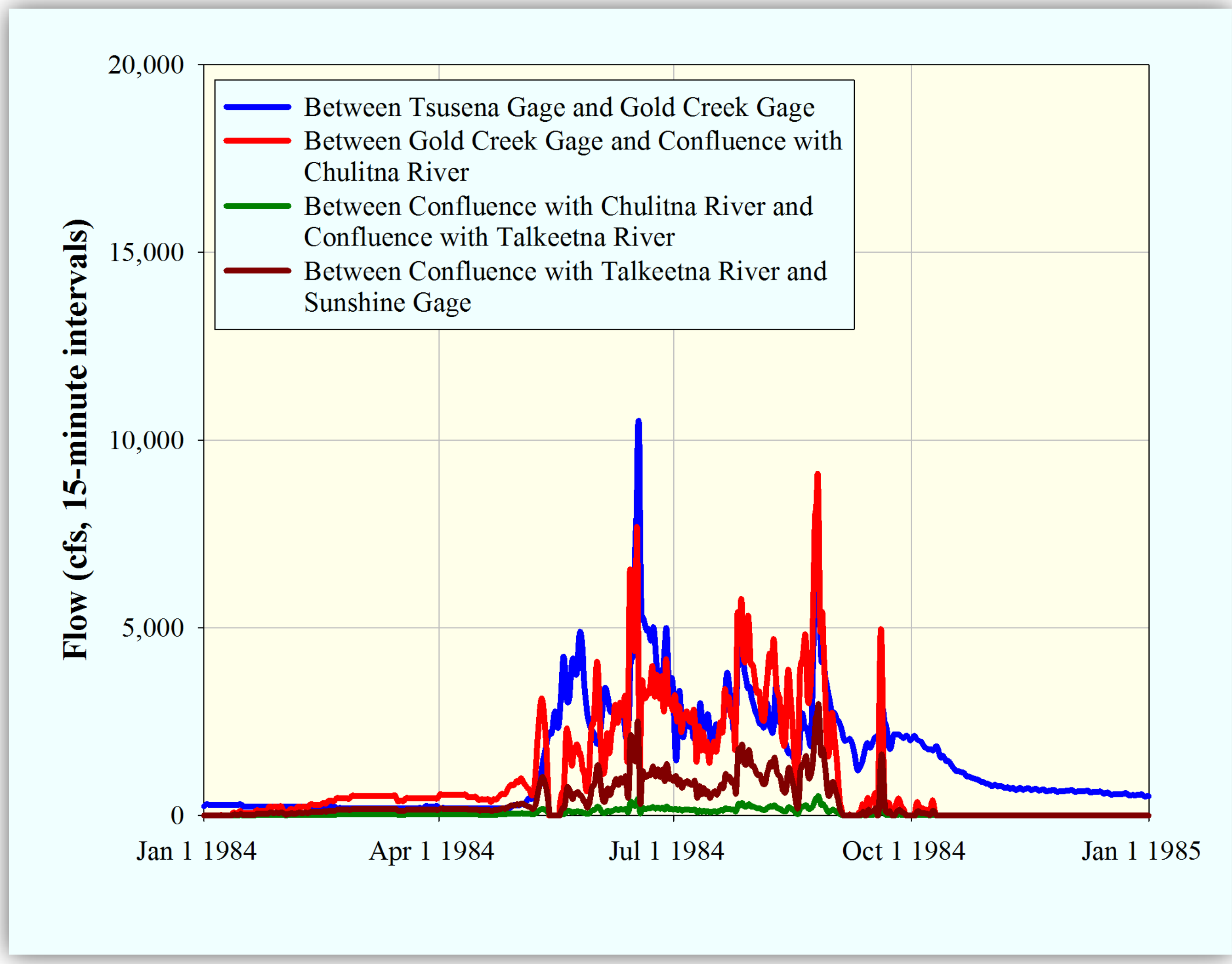


Figure 4.4-5. Ungaged lateral inflow hydrographs at 15-minute intervals to the Susitna River to four reaches between Tsusena Gage and Sunshine Gage during calendar year 1984.

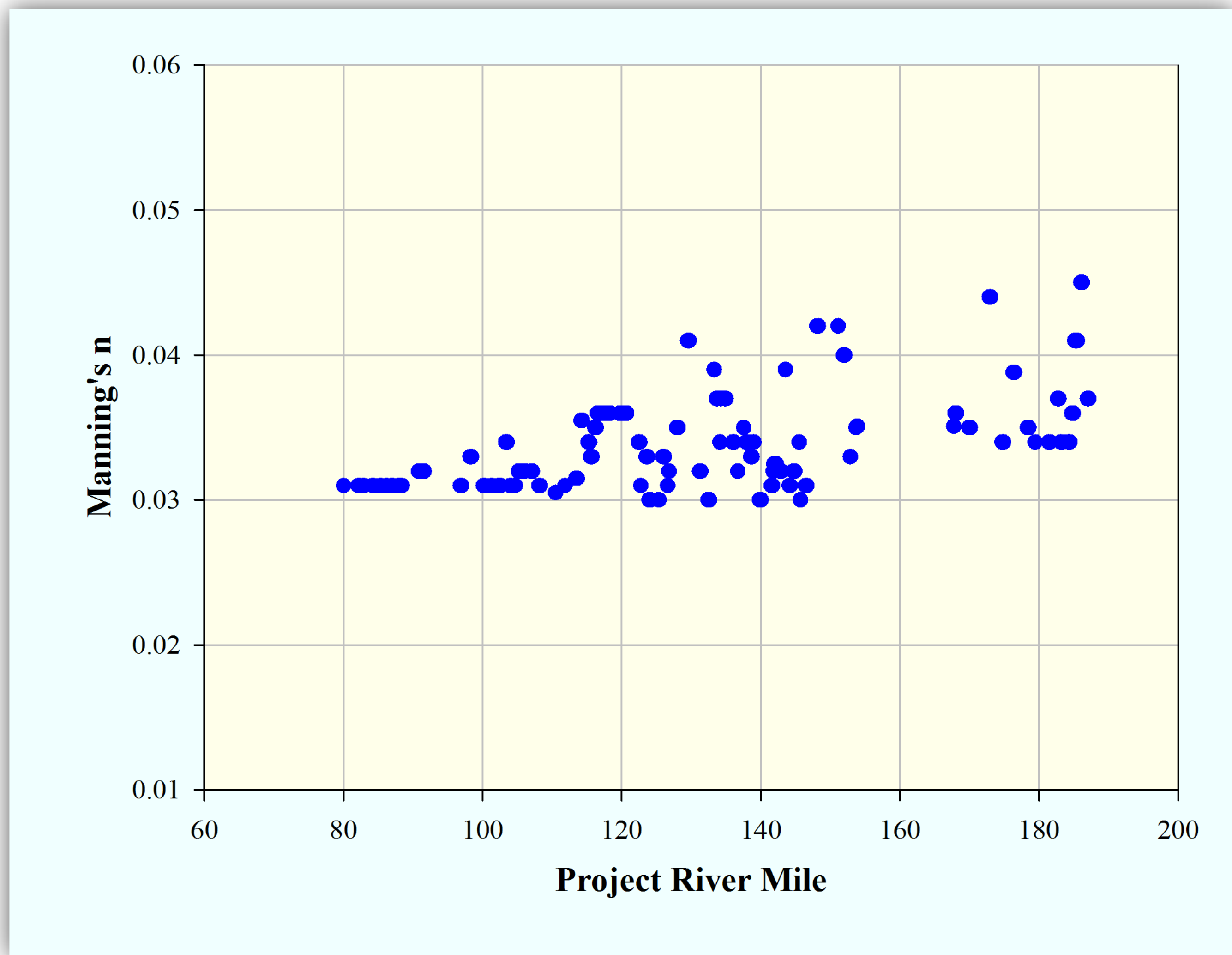


Figure 5.2-1. Manning's n channel roughness coefficients derived from steady-state calibration of flow routing model for 88 cross-sections of the Susitna River surveyed in 2012.

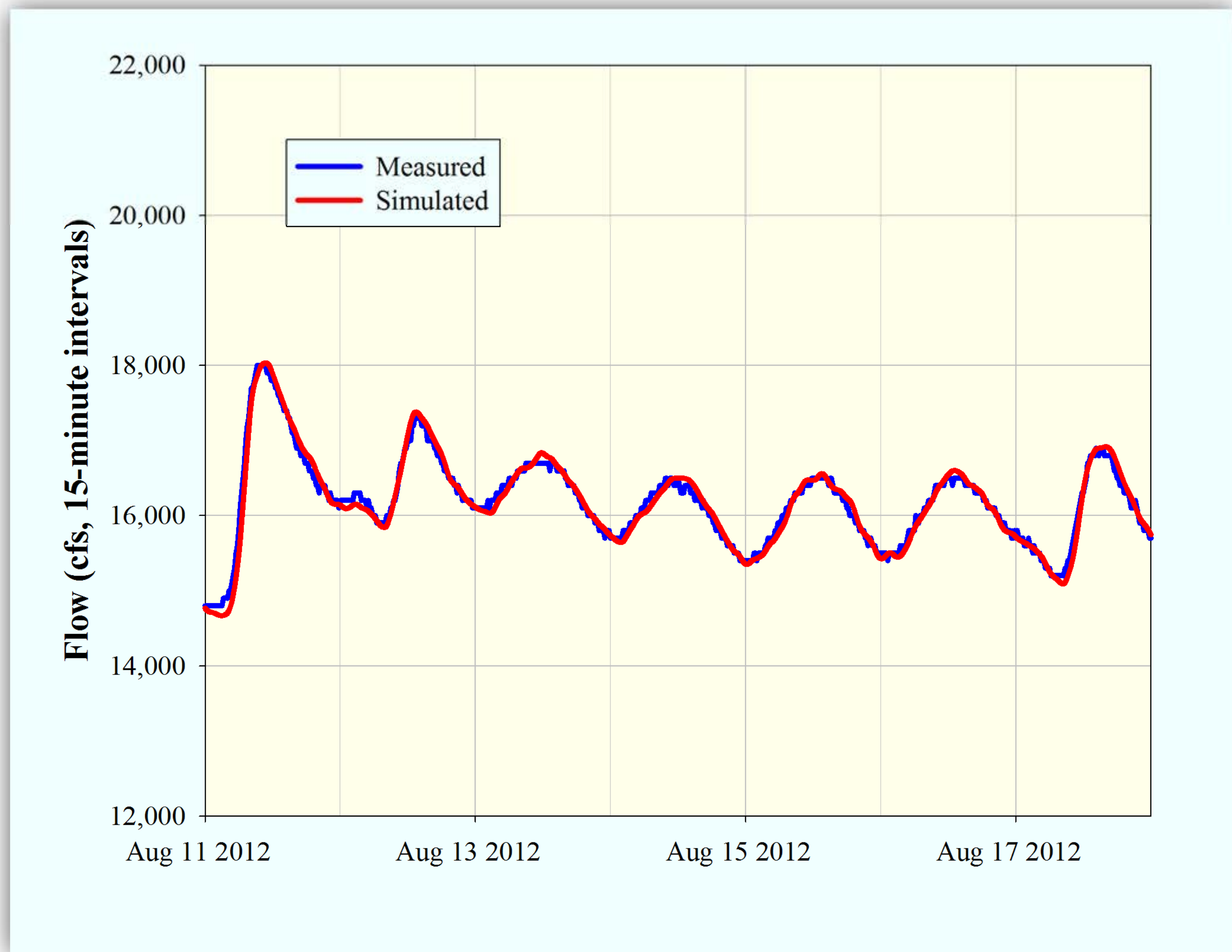


Figure 5.2-2. Comparison of measured versus simulated flow hydrographs in the Susitna River at Gold Creek (USGS 15292000) during the period from August 11 to August 17, 2012 when there were distinct diurnal flow fluctuations associated with glacial melt.

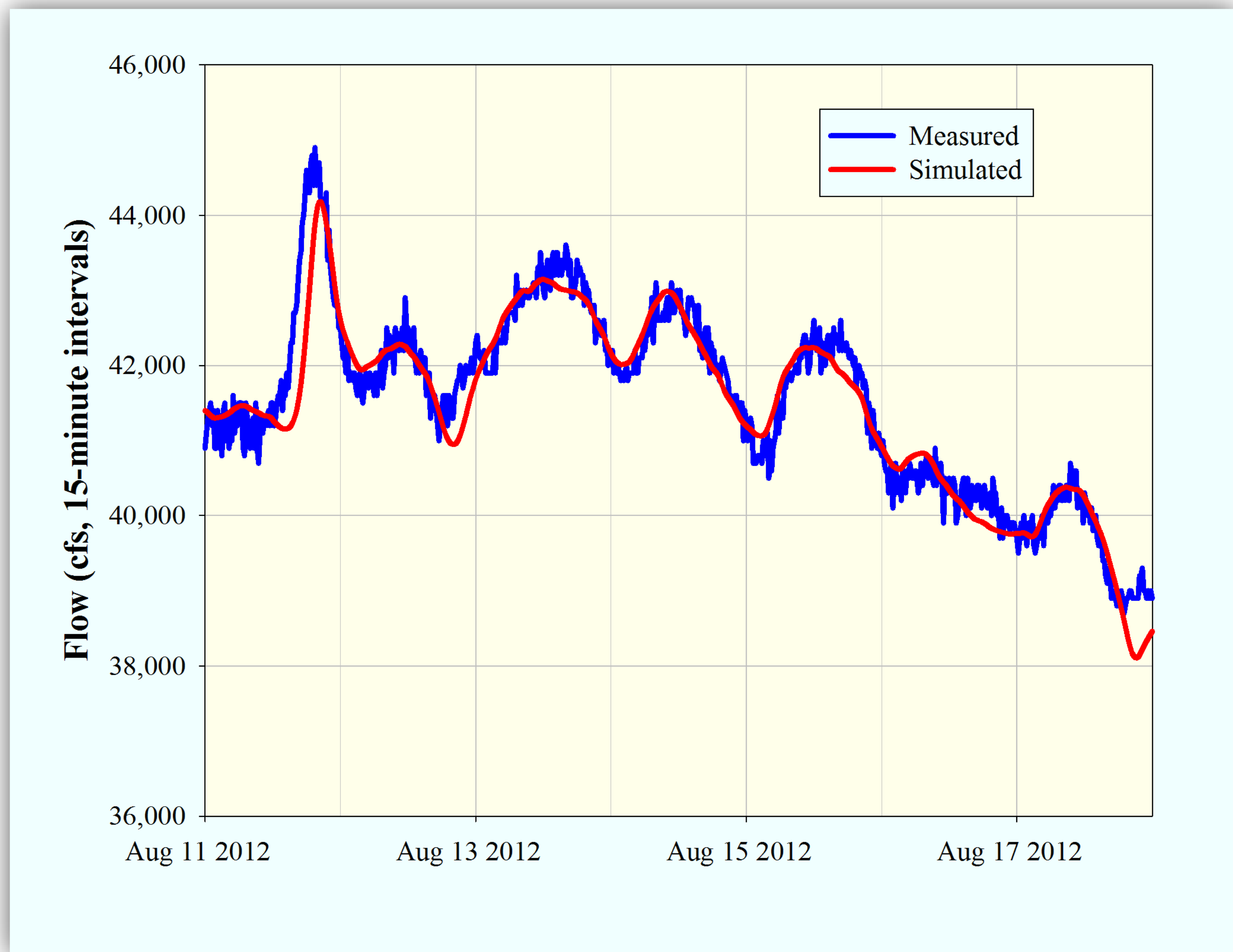


Figure 5.2-3. Comparison of measured versus simulated flow hydrographs in the Susitna River at Sunshine (USGS 15292780) during the period from August 11 to August 17, 2012 when there were distinct diurnal flow fluctuations associated with glacial melt.

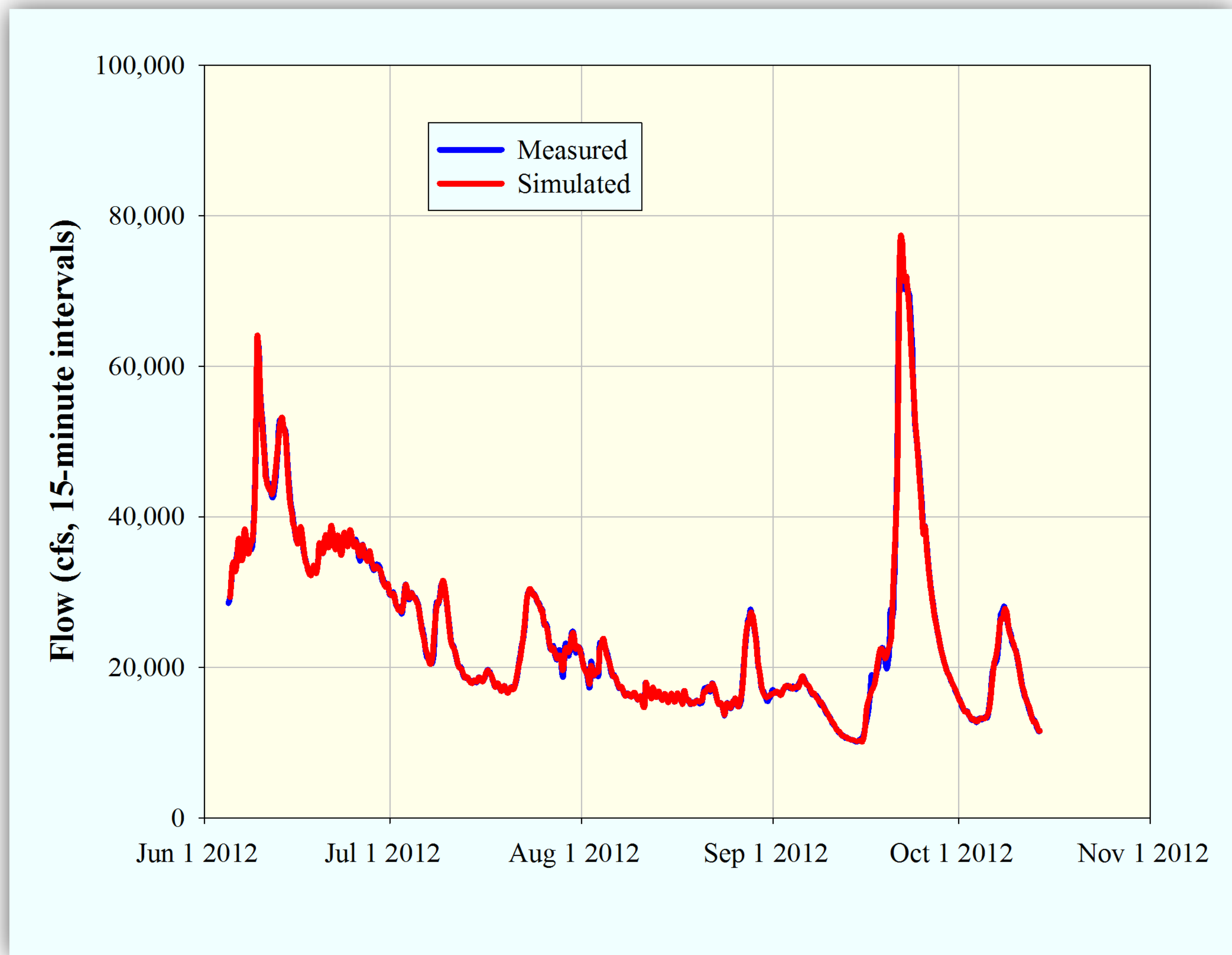


Figure 5.3-1. Comparison of measured versus simulated flow hydrographs in the Susitna River at Gold Creek (USGS 15292000) during the period from June 4 to October 14, 2012.

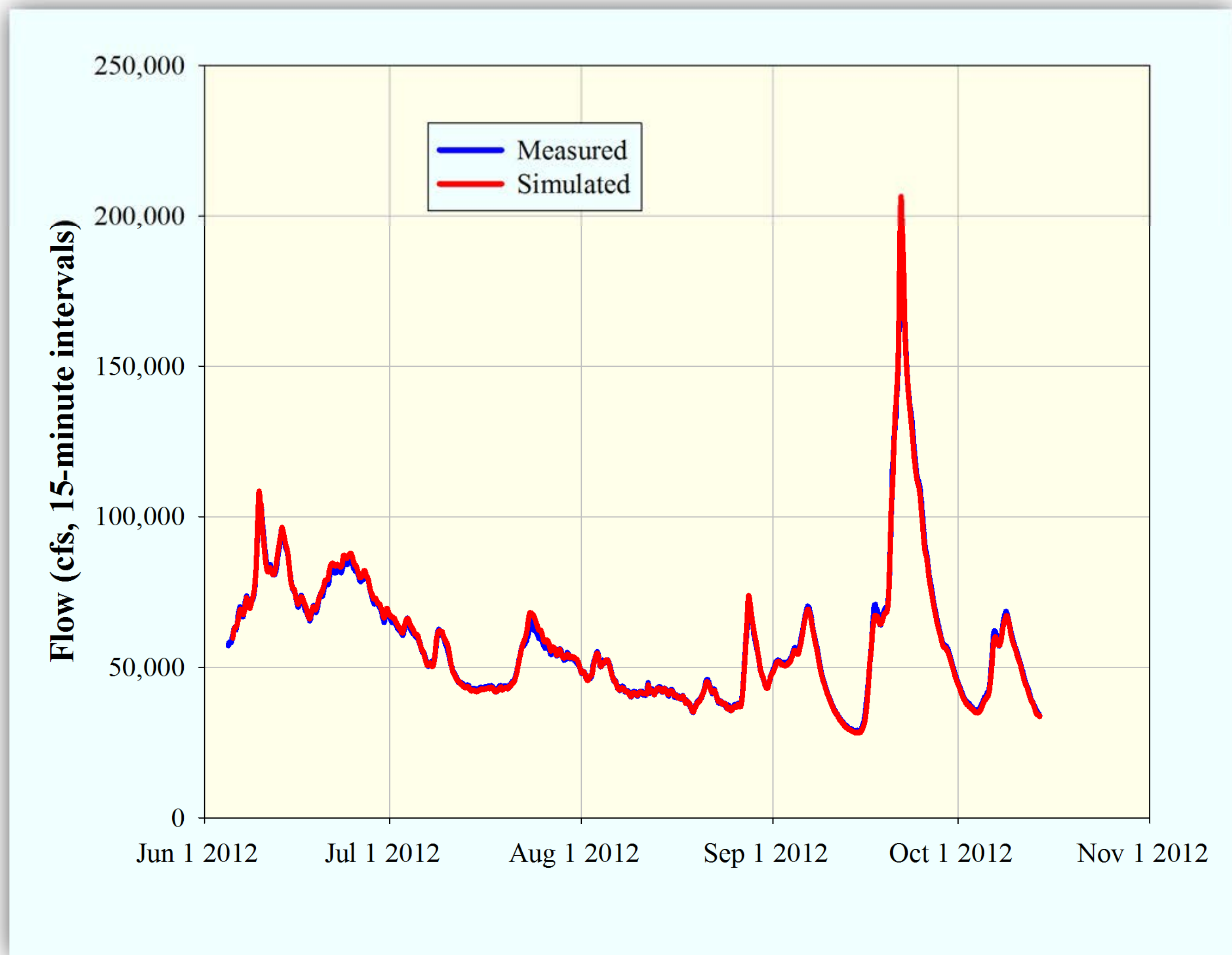


Figure 5.3-2. Comparison of measured versus simulated flow hydrographs in the Susitna River at Sunshine (USGS 15292780) during the period from June 4 to October 14, 2012.

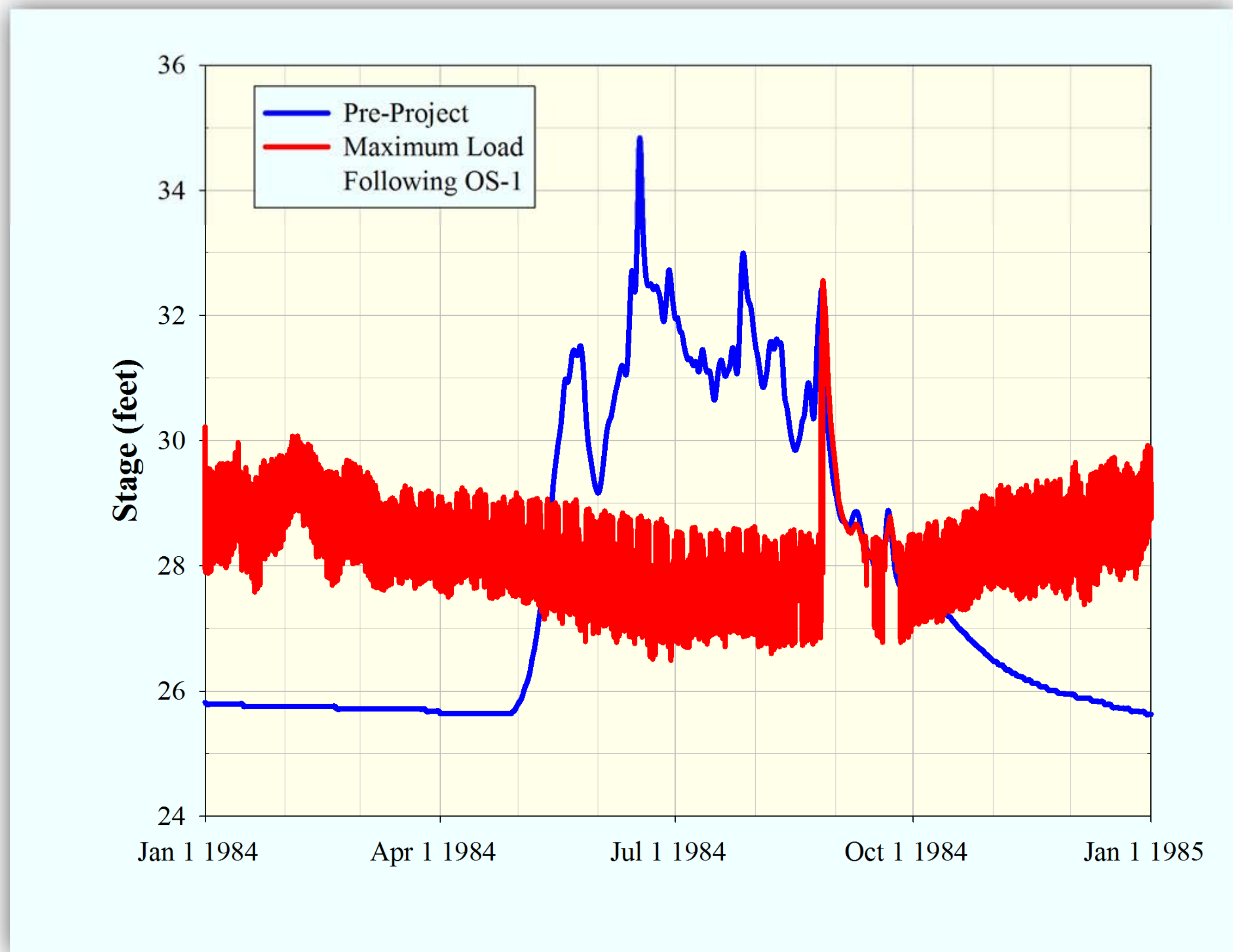


Figure 5.4-1. Predicted stage hydrographs in the Susitna River below Watana Dam Site under Pre-Project and Maximum Load Following OS-1 conditions for calendar year 1984. This portion of the Susitna River is expected to remain ice-free under Maximum Load Following OS-1 conditions.

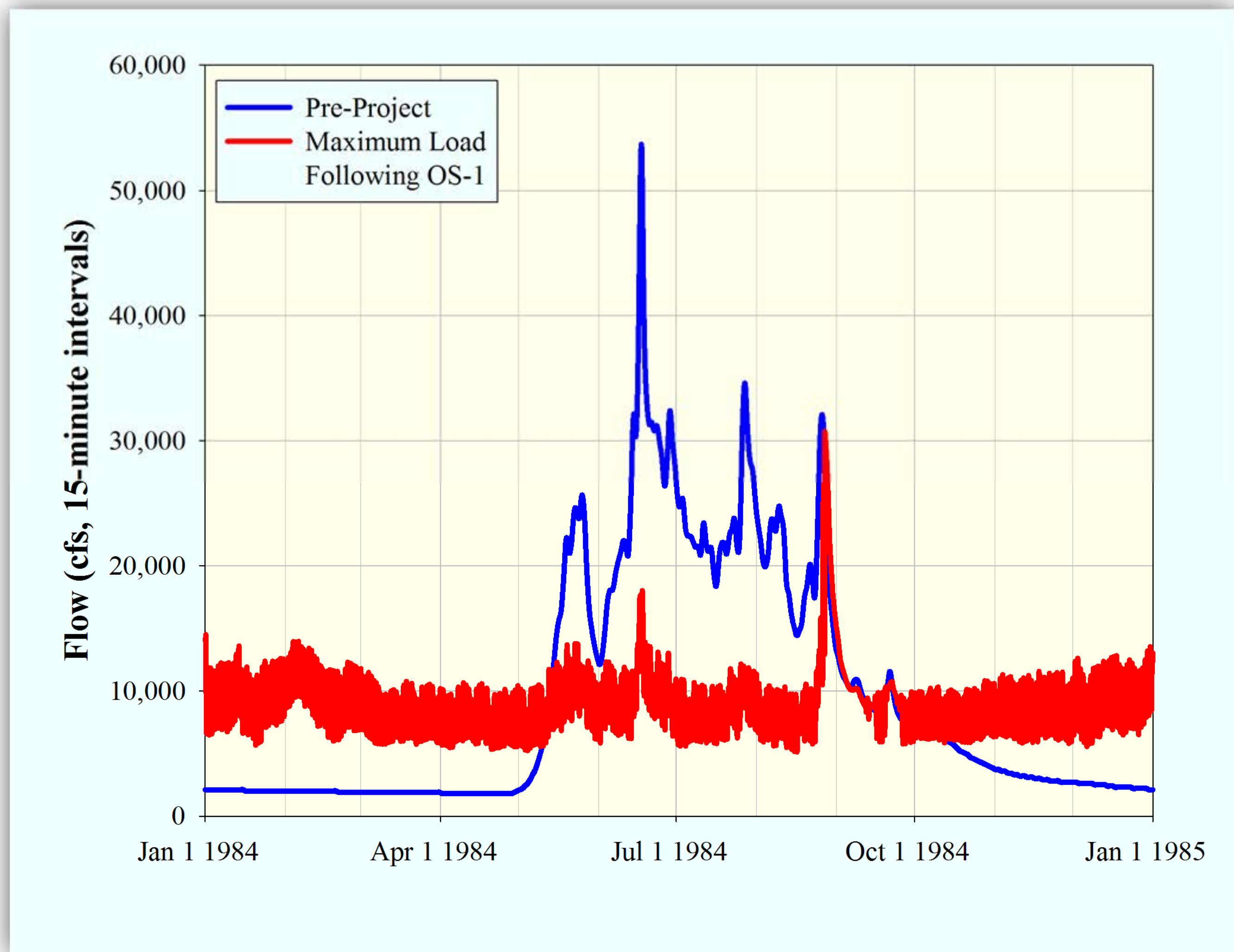


Figure 5.4-2. Predicted flow hydrographs in the Susitna River at Gold Creek (USGS 15292000) under Pre-Project and Maximum Load Following OS-1 conditions for calendar year 1984. Actual results may differ from those depicted as a result of ice formation in the river.

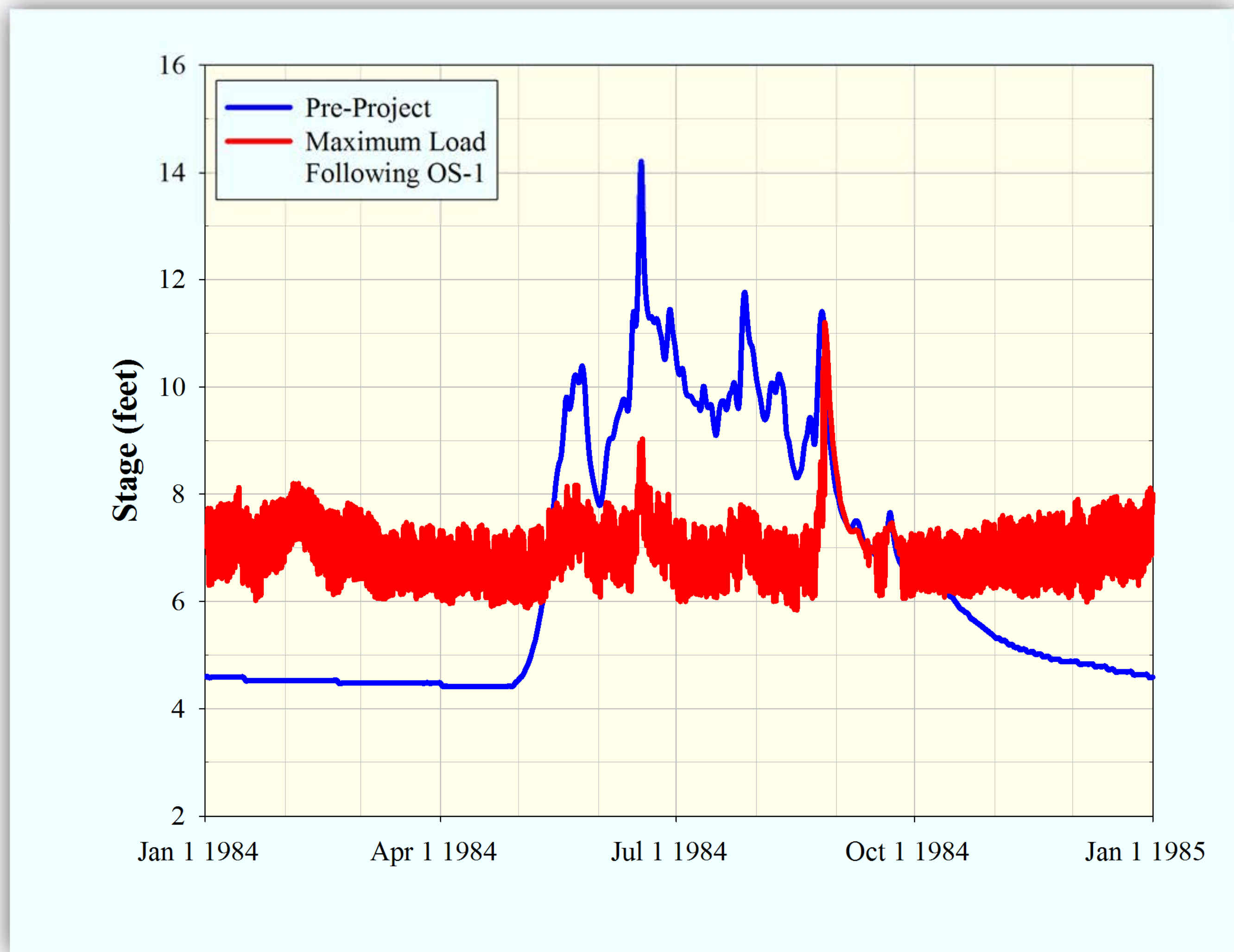
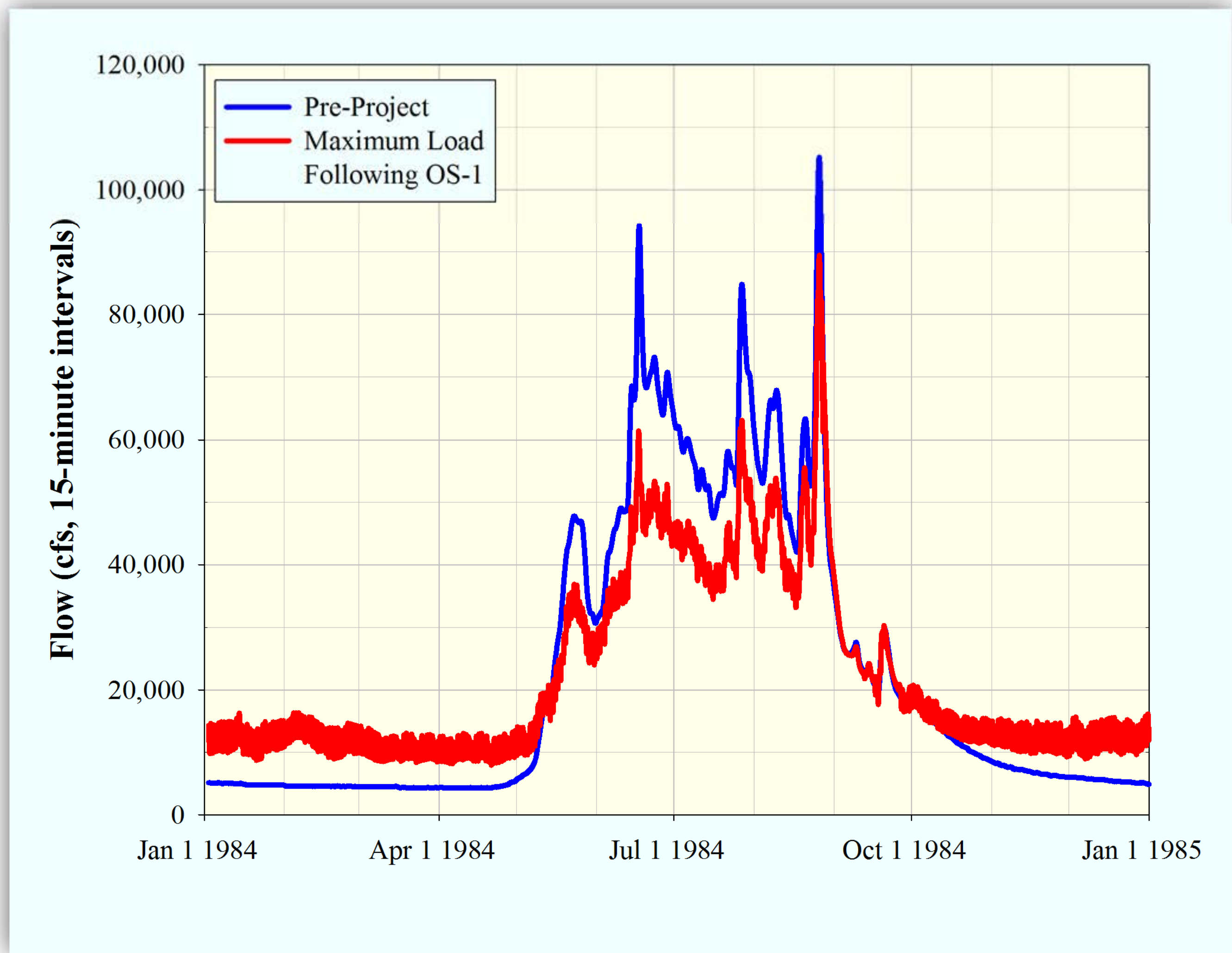


Figure 5.4-3. Predicted stage hydrographs in the Susitna River at Gold Creek (USGS 15292000) under Pre-Project and Maximum Load Following OS-1 conditions for calendar year 1984. Actual results may differ from those depicted as a result of ice formation in the river.



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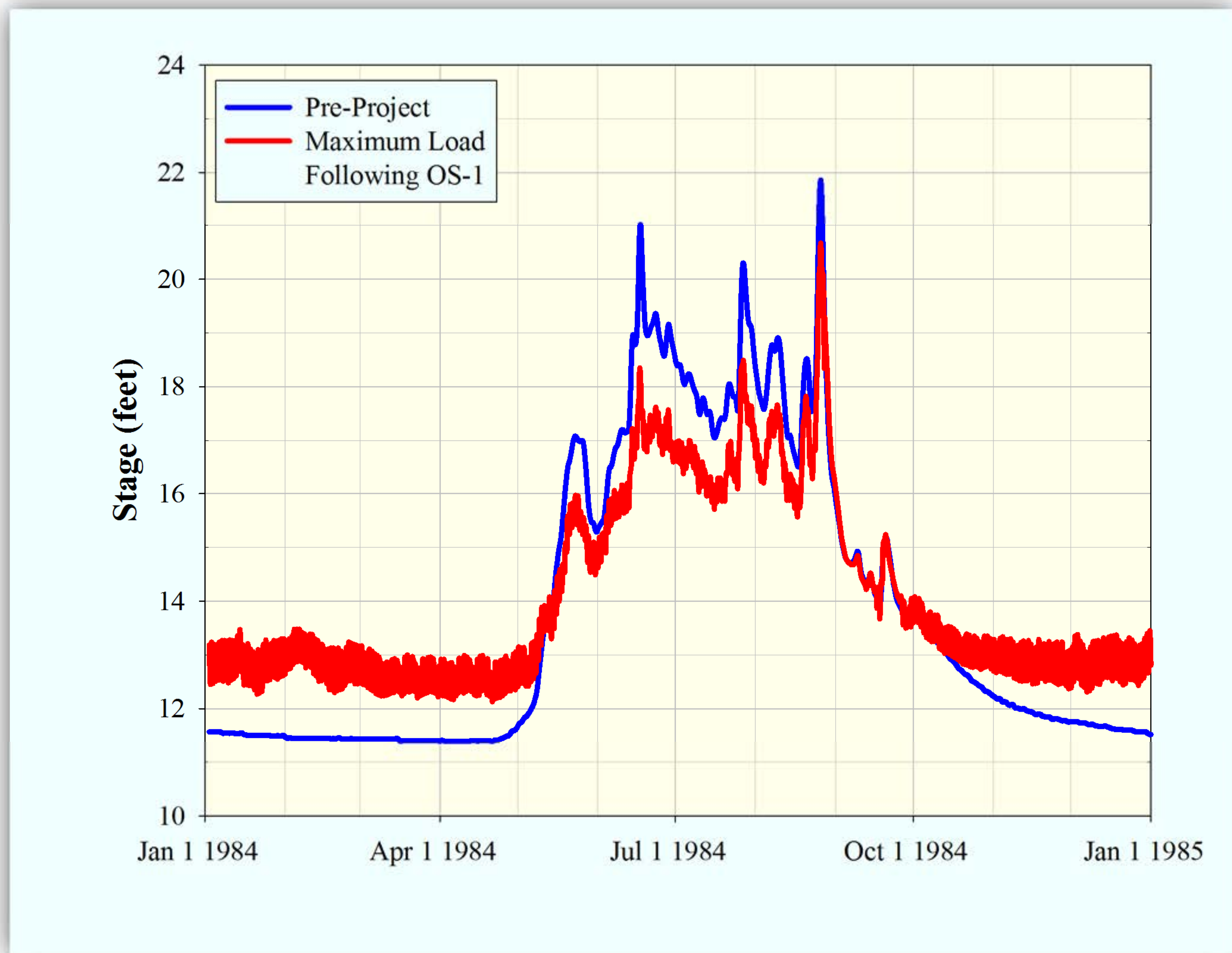

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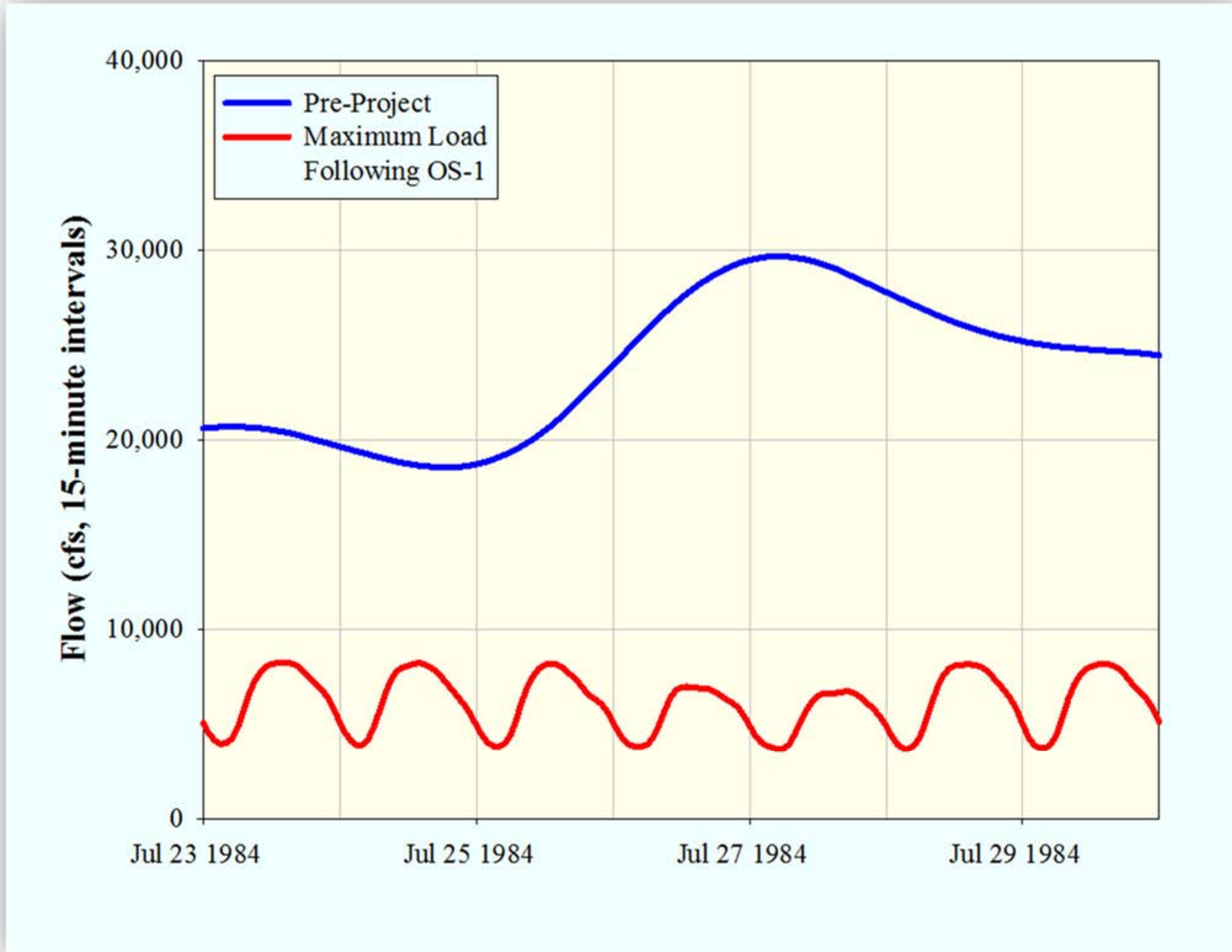


Figure 5.4-6. Flow releases from Watana Dam site, input to the flow routing model for the Pre-Project and Maximum Load Following OS-1 scenarios during the week of July 23 to July 29, 1984. Pre-Project conditions do not account for potential diurnal fluctuations associated with glacial melt.

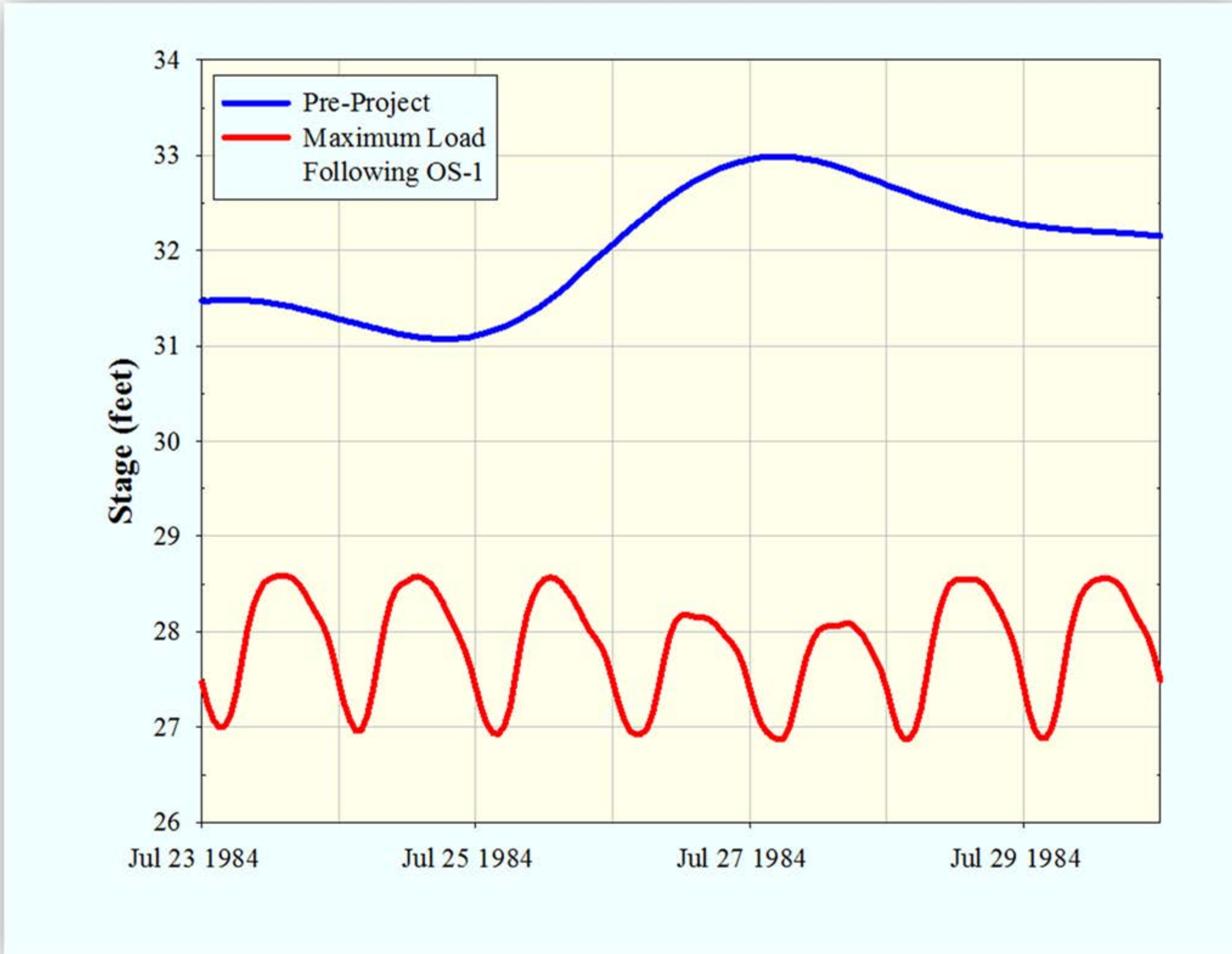
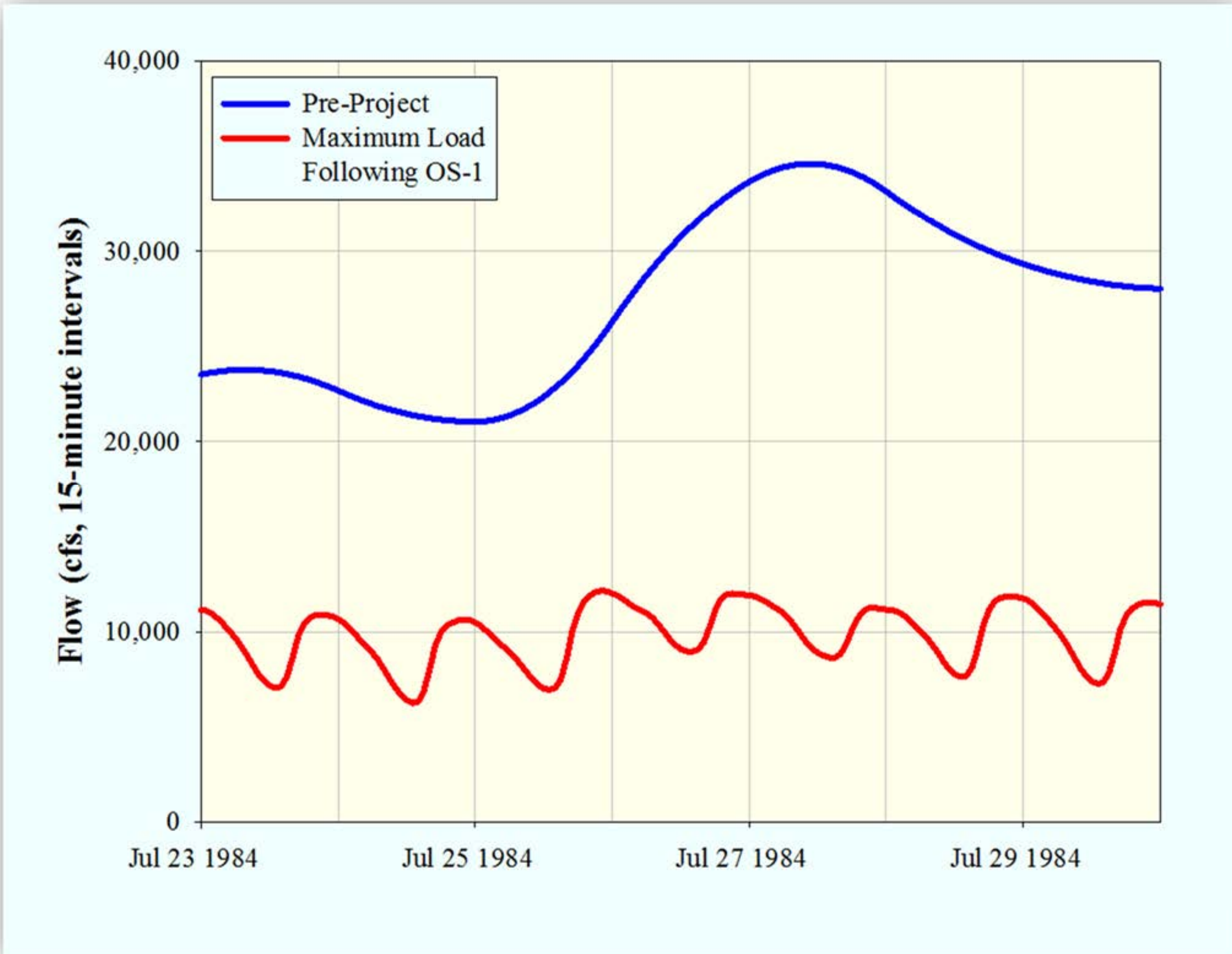


Figure 5.4-7. Predicted stage hydrographs in the Susitna River below Watana Dam Site under Pre-Project and Maximum Load Following OS-1 conditions during the week of July 23 to July 29, 1984. Pre-Project conditions do not account for potential diurnal fluctuations associated with glacial melt.



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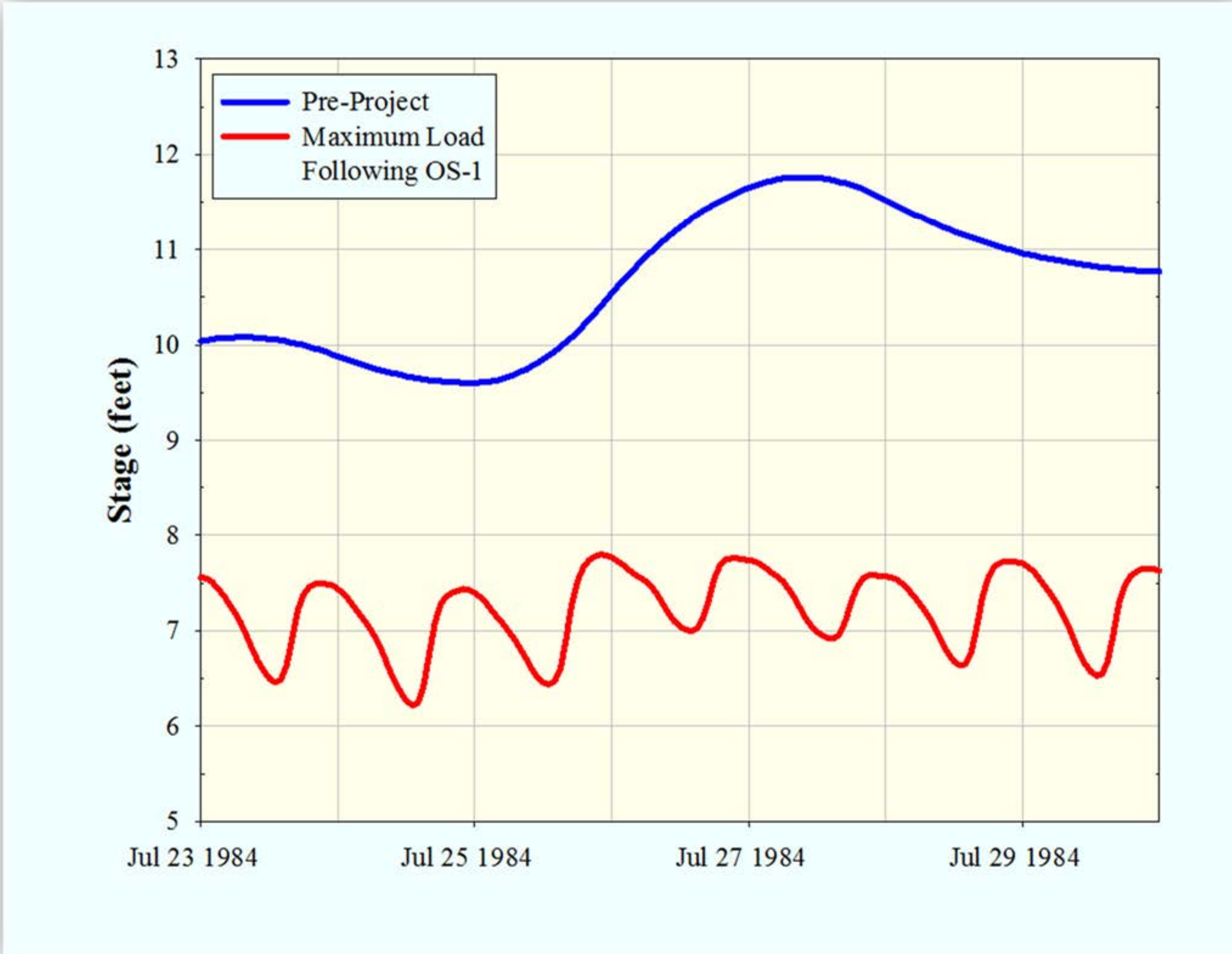


Figure 5.4-9. Predicted stage hydrographs in the Susitna River at Gold Creek (USGS 15292000) under Pre-Project and Maximum Load Following OS-1 conditions during the week of July 23 to July 29, 1984. Pre-Project conditions do not account for potential diurnal fluctuations associated with glacial melt.

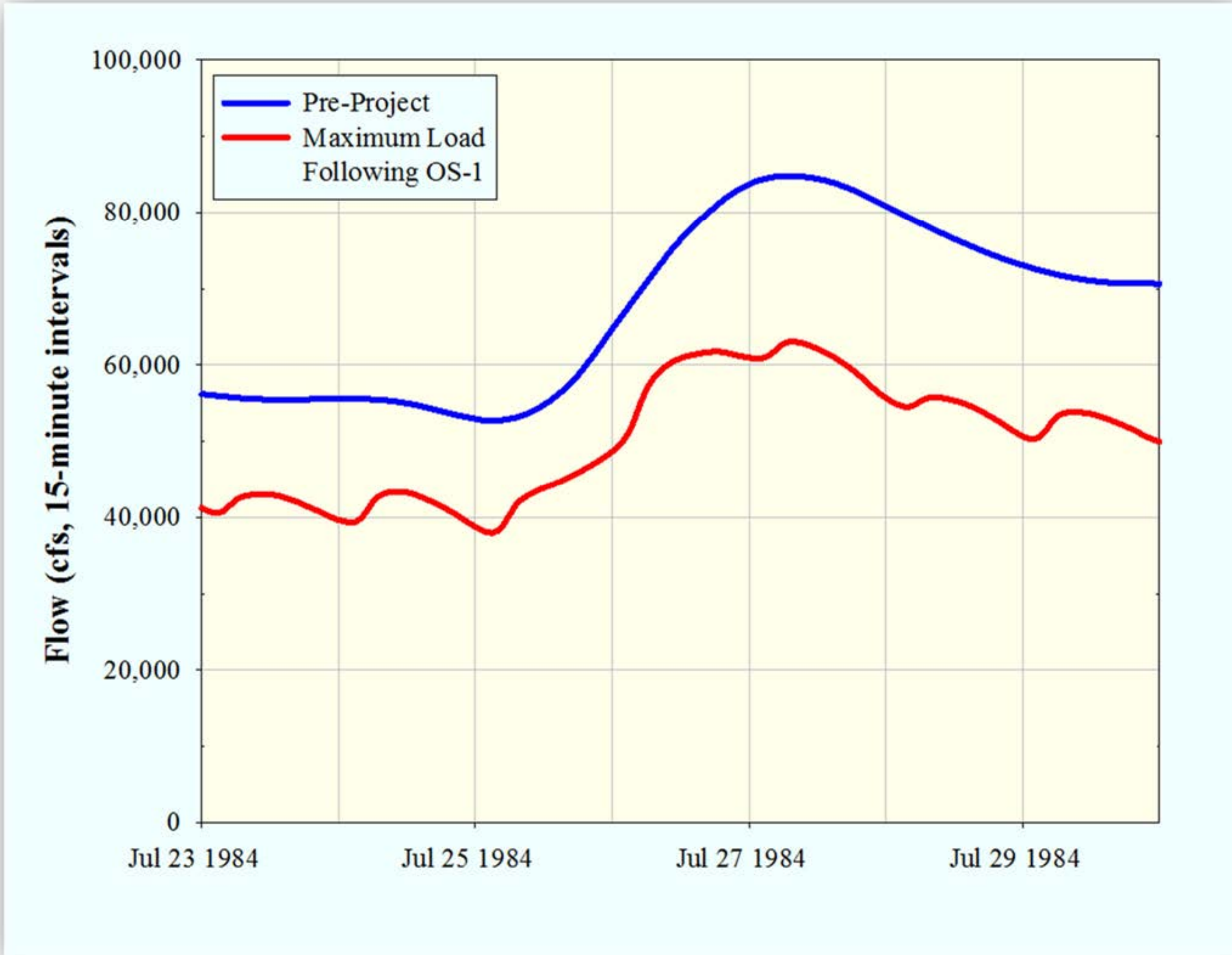


Figure 5.4-10. Predicted flow hydrographs in the Susitna River at Sunshine (USGS 15292780) under Pre-Project and Maximum Load Following OS-1 conditions during the week of July 23 to July 29, 1984. Pre-Project conditions do not account for potential diurnal fluctuations associated with glacial melt.

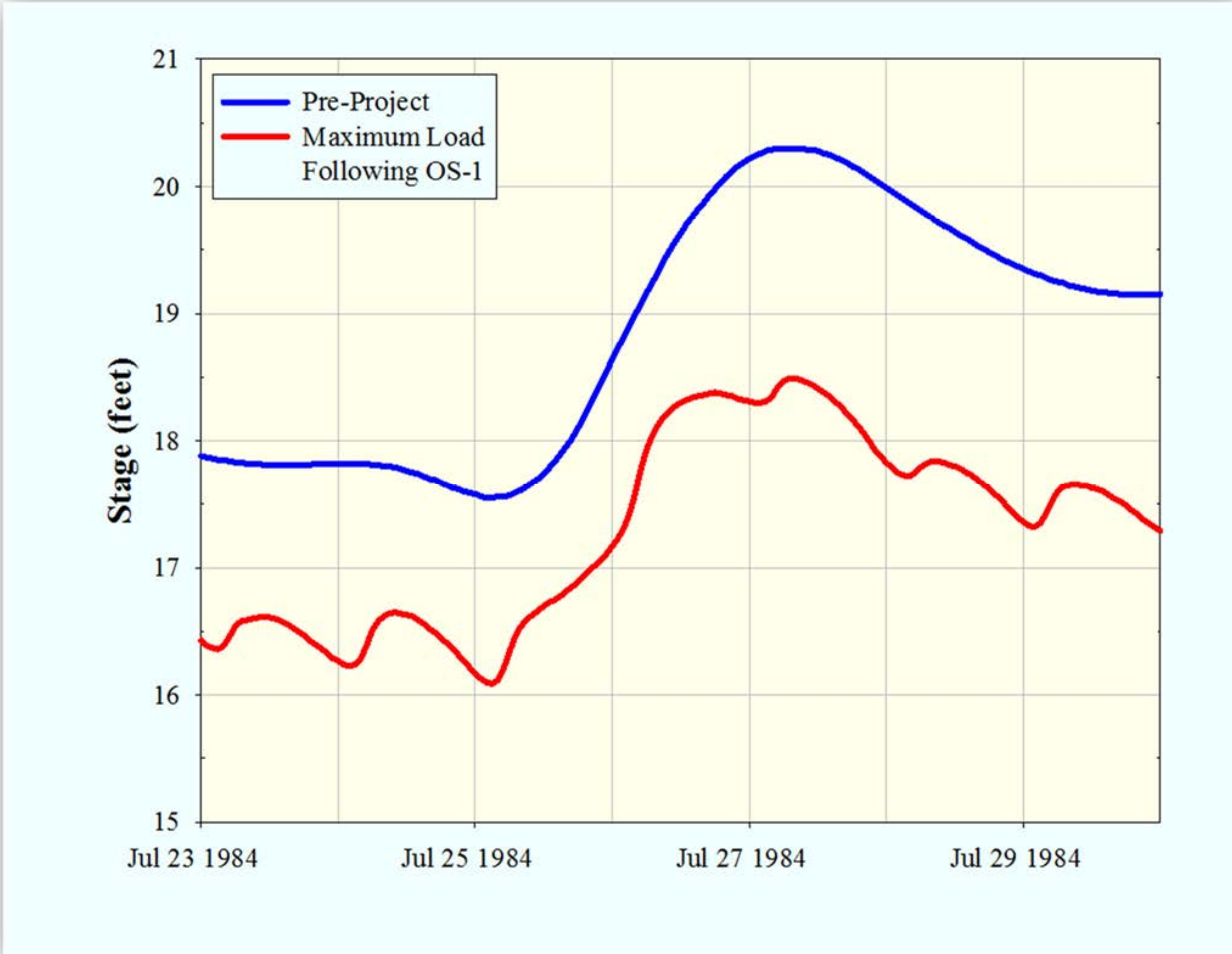


Figure 5.4-11. Predicted stage hydrographs in the Susitna River at Sunshine (USGS 15292780) under Pre-Project and Maximum Load Following OS-1 conditions during the week of July 23 to July 29, 1984. Pre-Project conditions do not account for potential diurnal fluctuations associated with glacial melt.

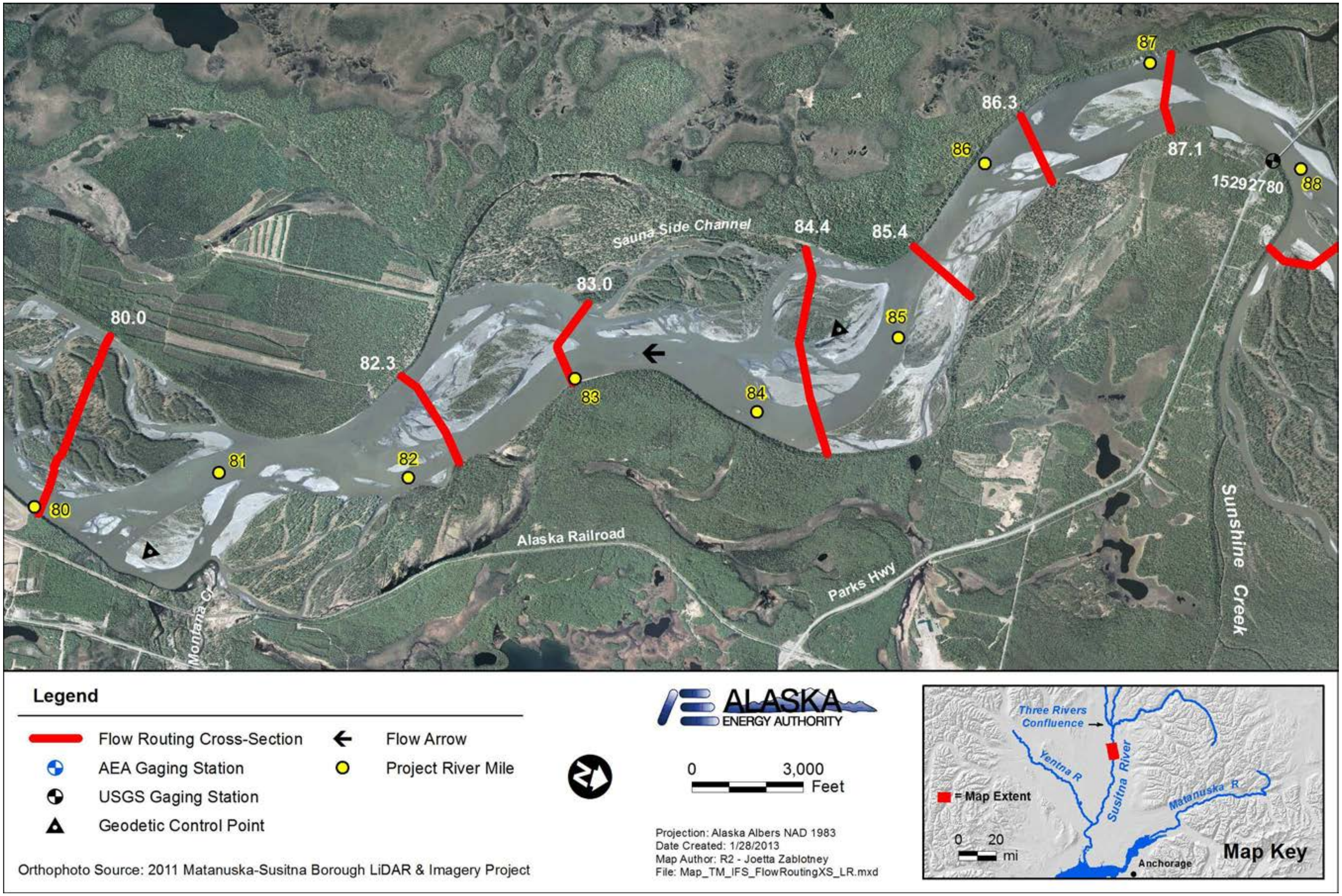
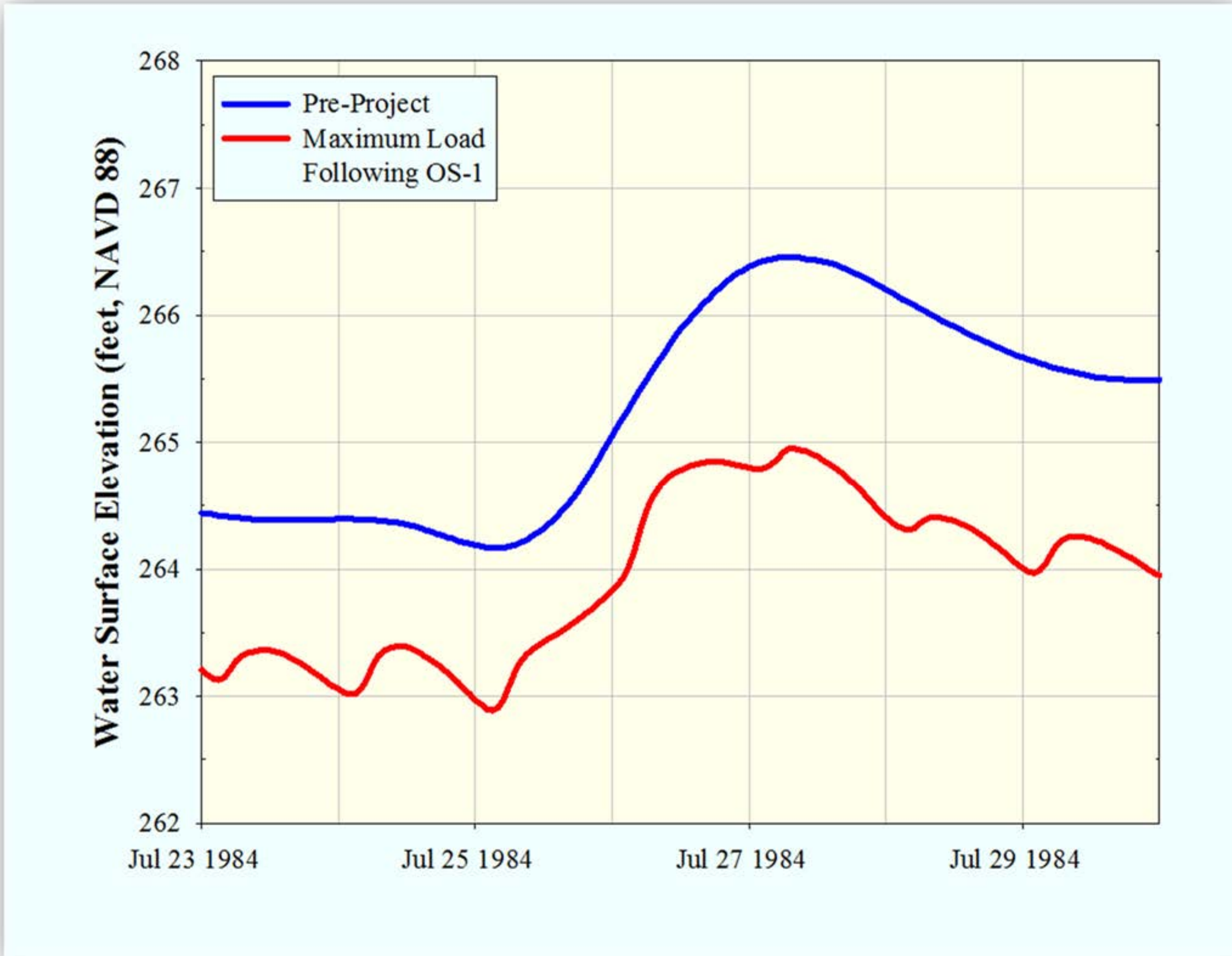


Figure 5.4-12. Location of USGS gage on highway bridge in upper right hand corner of photo. The Susitna River is a confined single channel in the vicinity of the gage, and not representative of the overall river.



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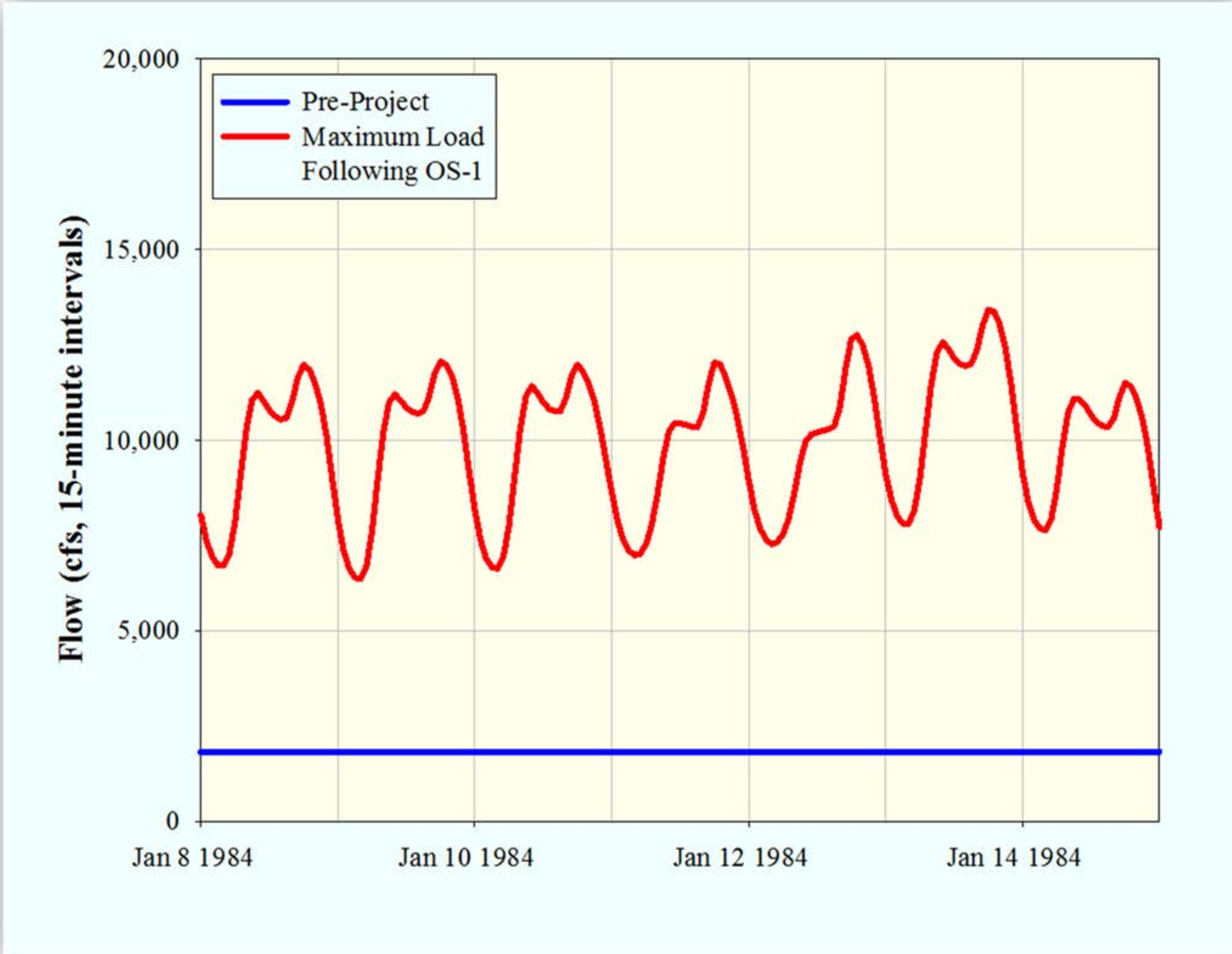
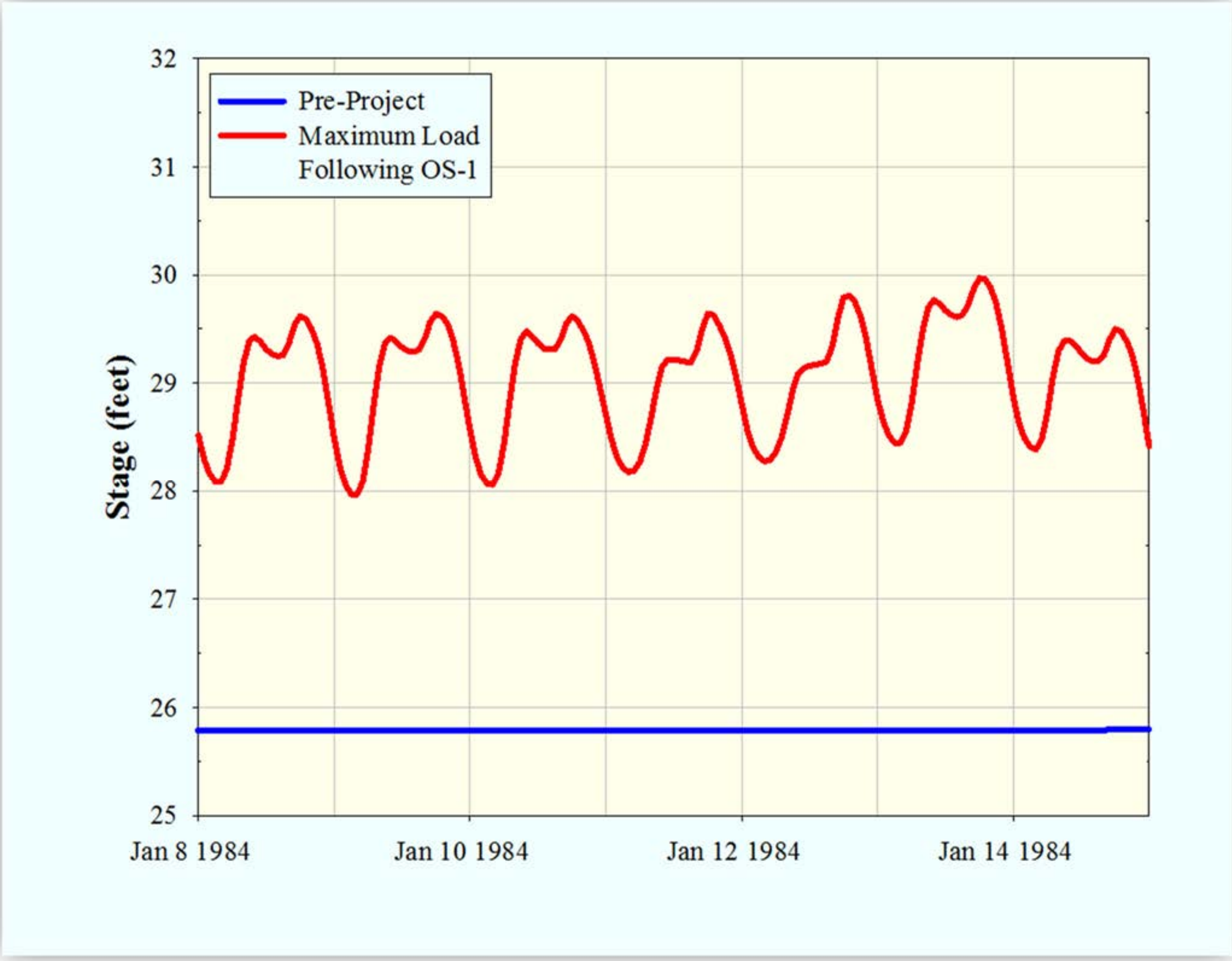


Figure 5.4-14. Flow releases from Watana Dam site, input to the flow routing model for the Pre-Project and Maximum Load Following OS-1 scenarios during the week of January 8 to January 14 1984.



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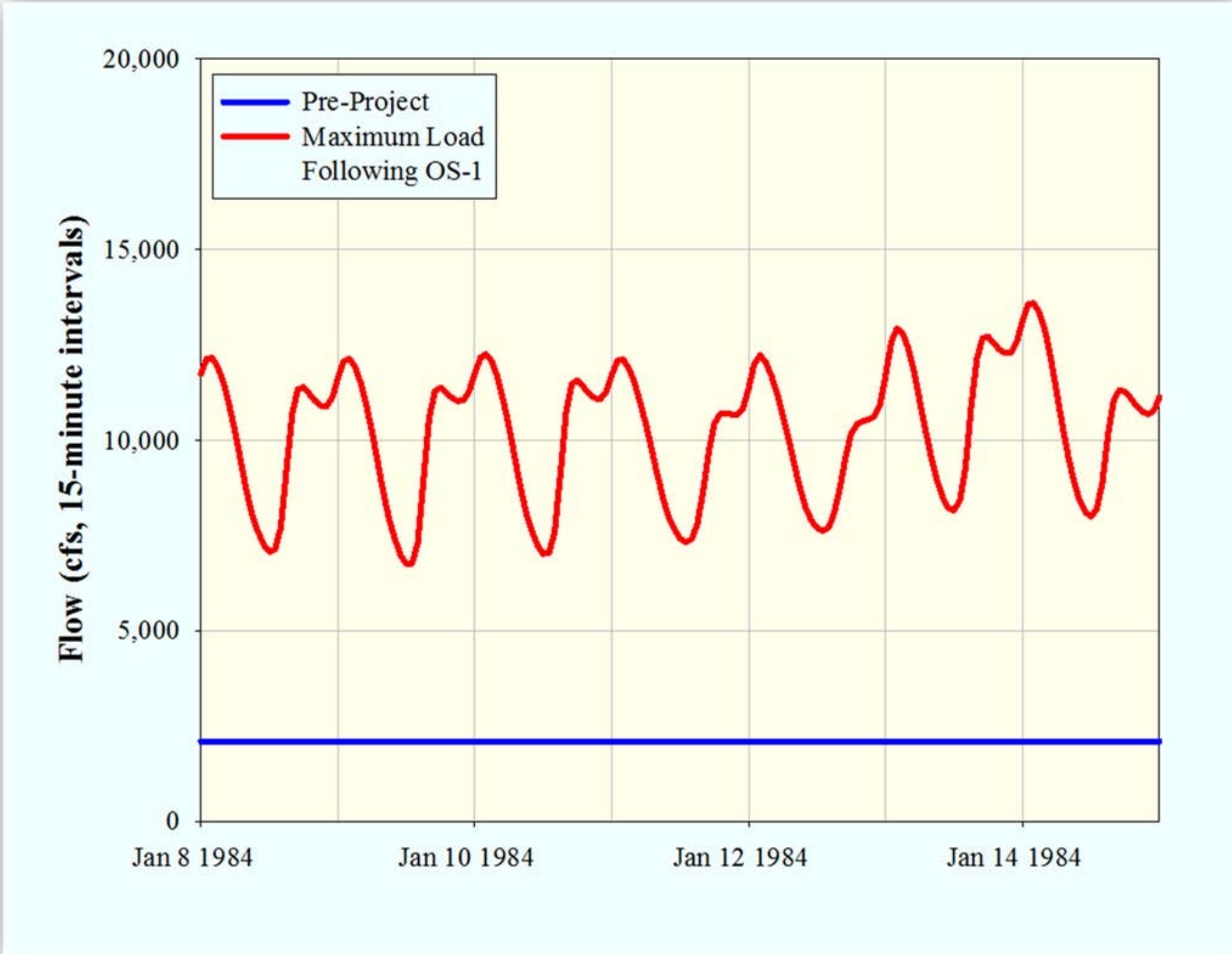

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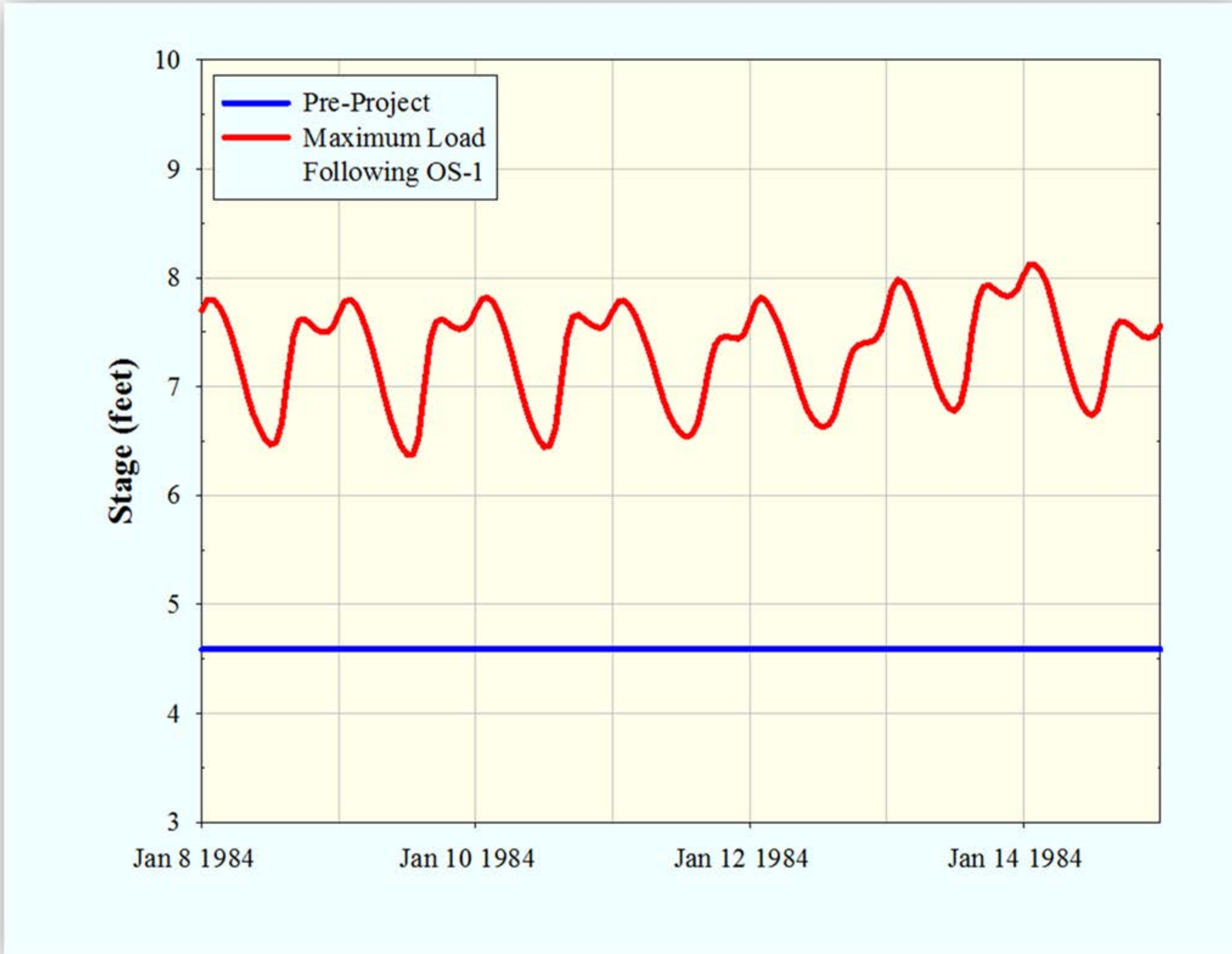

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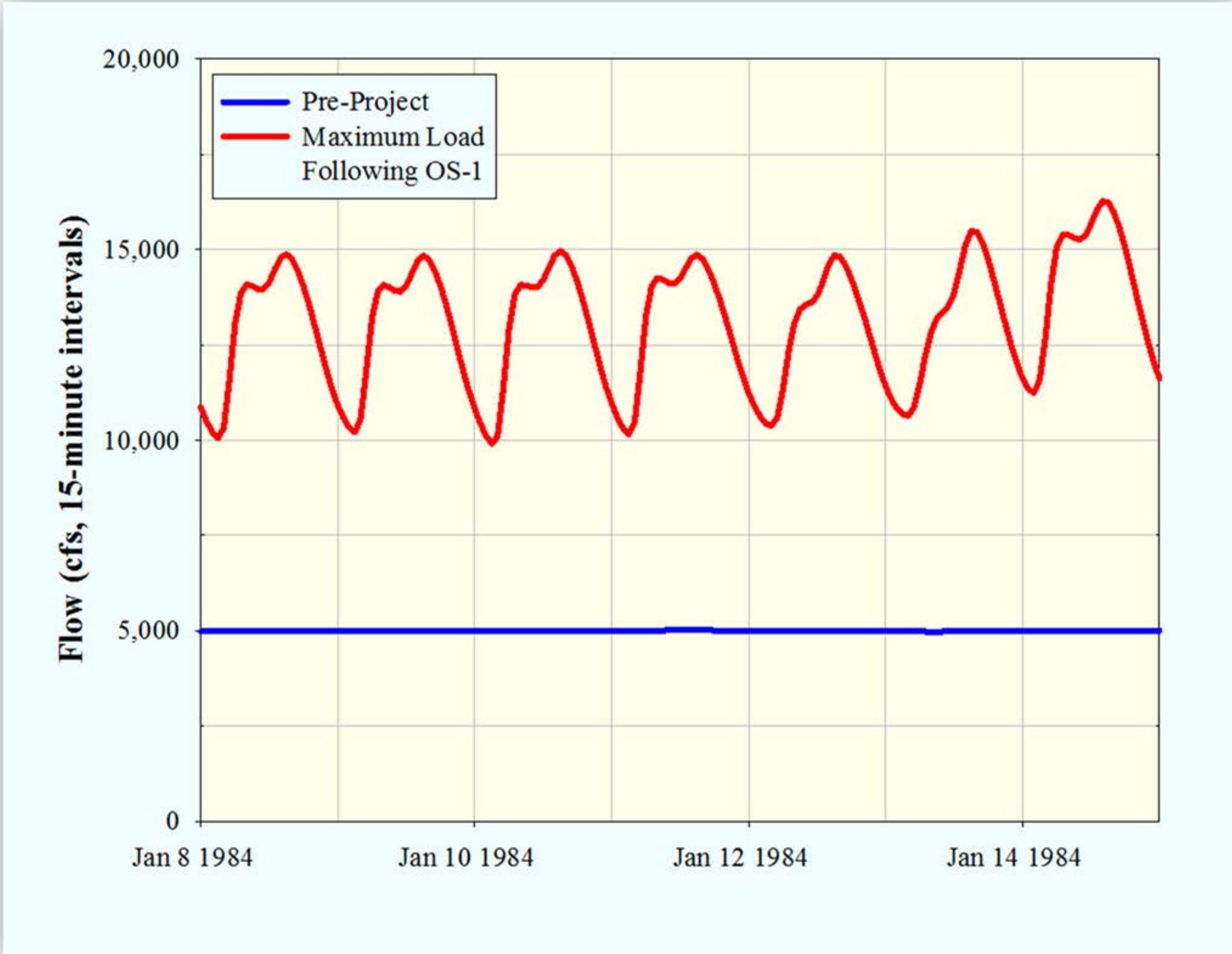

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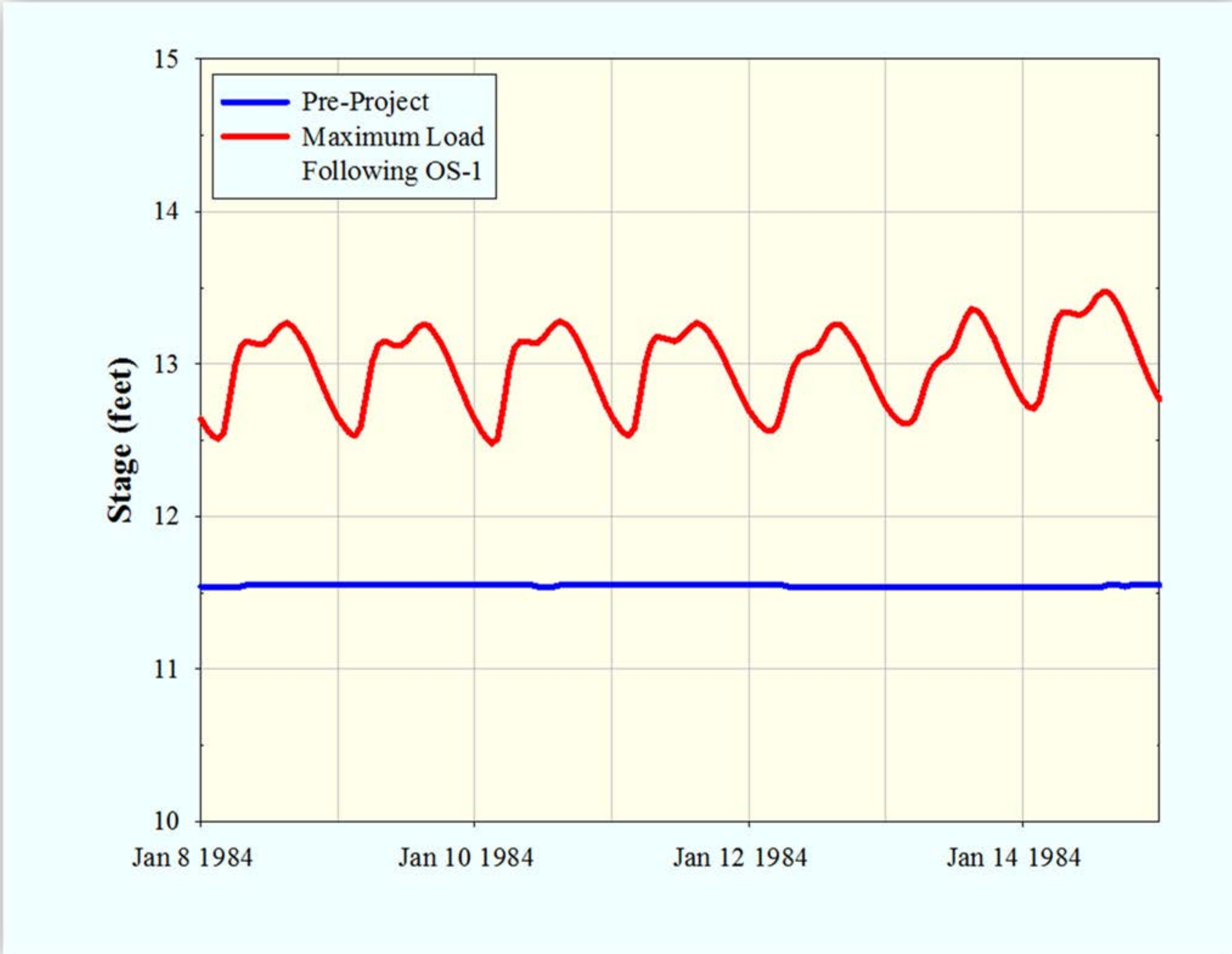

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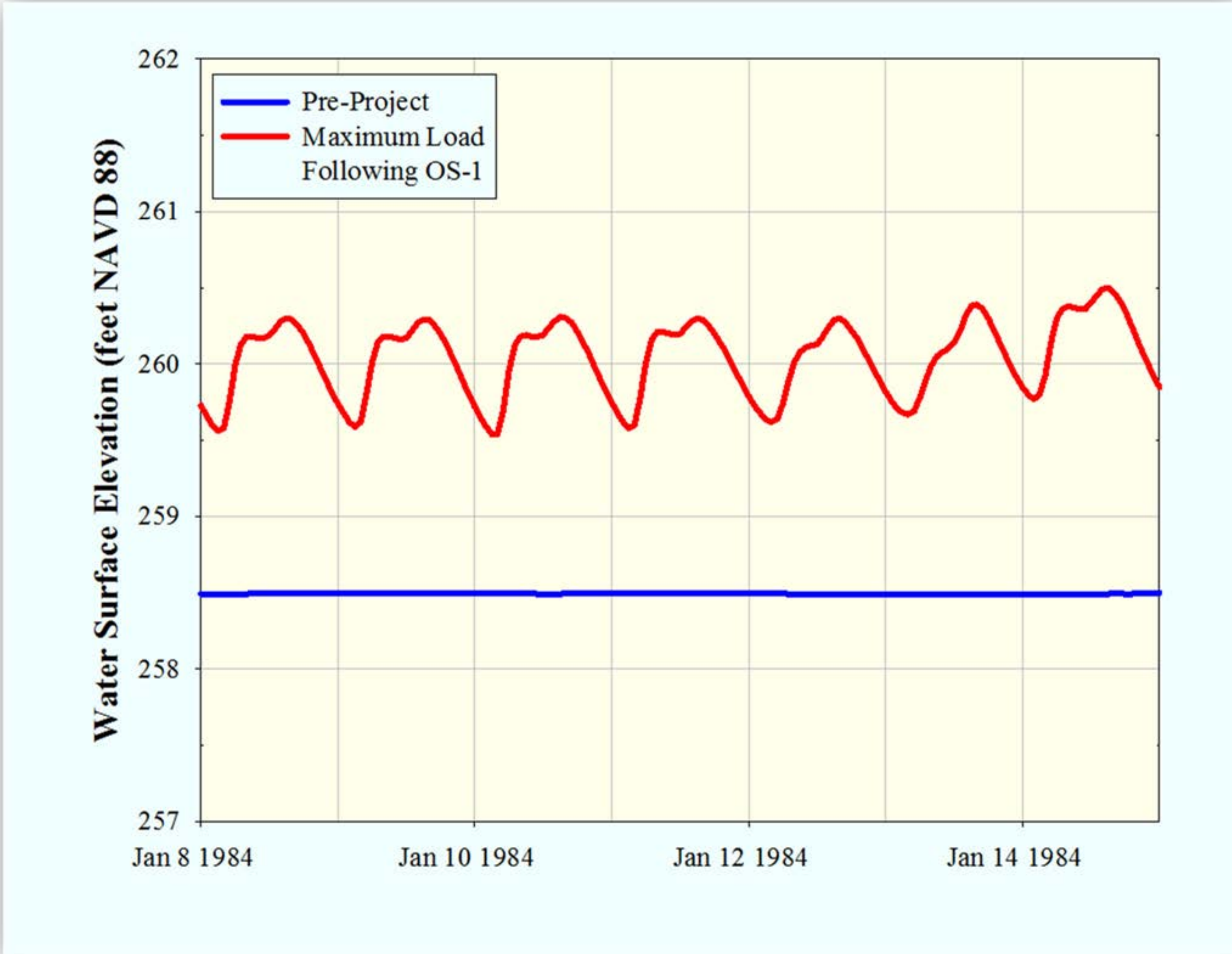

Figure 5.4-20. Predicted stage hydrographs in the Susitna River PRM 87.1 under Pre-Project and Maximum Load Following OS-1 conditions during the week of January 8 to 14, 1984. Actual results may differ from those depicted as a result of ice formation in the river.

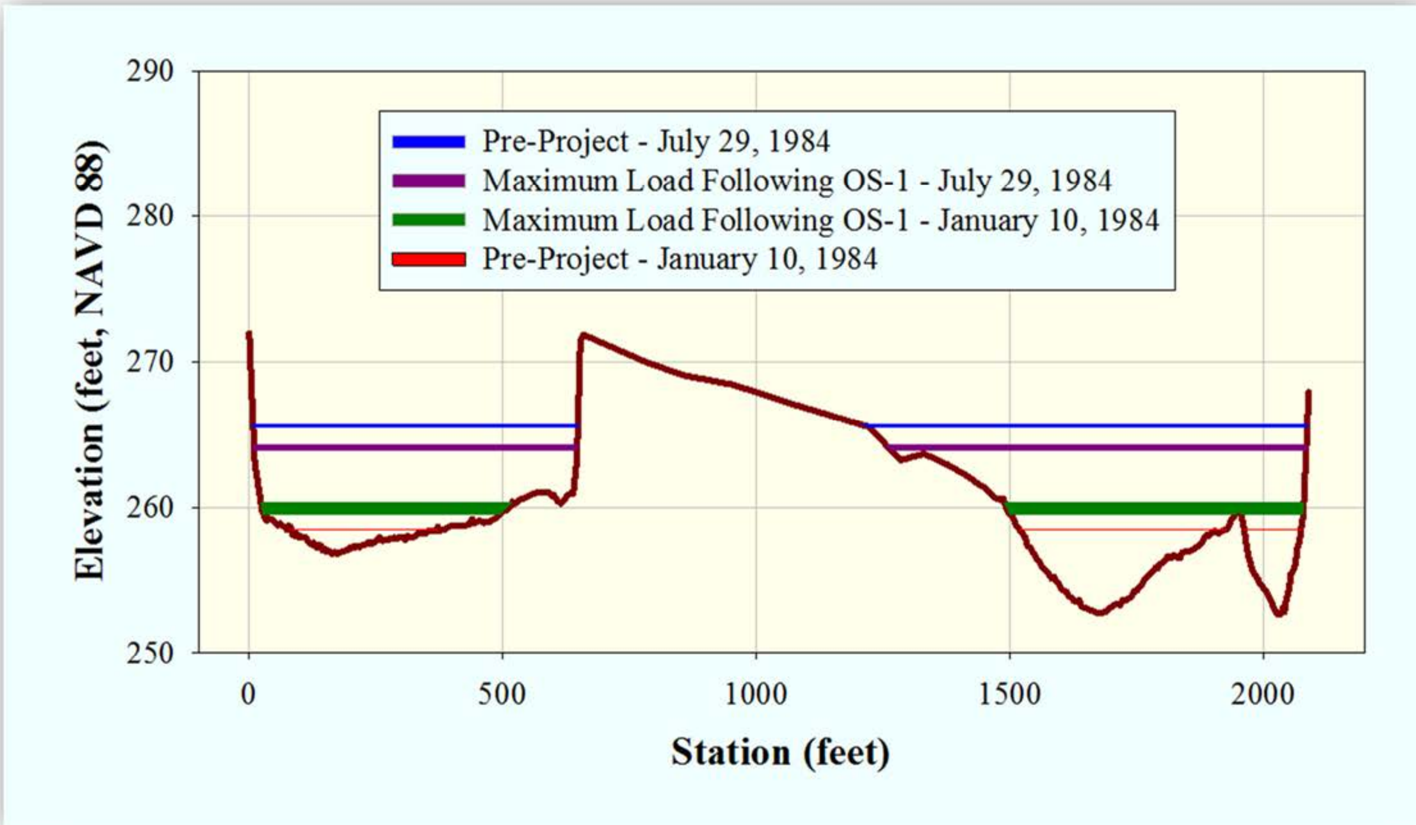

Figure 5.4-21. Range of daily stage fluctuations in the Susitna River cross-section at PRM 87.1 under Pre-Project and Maximum Load Following OS-1 conditions on January 10, 1984 and July 29, 1984. The thickness of each water surface elevation line was scaled to represent the range between minimum and maximum water surface elevation each day.

APPENDIX 1. WR-S1 RESERVOIR AND RIVER FLOW ROUTING MODEL TRANSECT DATA COLLECTION STUDY

Susitna-Watana Hydroelectric Project
(FERC No. 14241)

APPENDIX 1

WR-S1 Reservoir and River Flow Routing Model Transect Data Collection Study

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

Geo-Watersheds Scientific

Brailey Hydrologic

Geovera

R2 Resource Consultants

January 31, 2013

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Abbreviation	Definition
ADCP	Acoustic Doppler Current Profiler
AEA	Alaska Energy Authority
ASPLS	Alaska Society of Professional Land Surveyors
AT	air temperature
AVC	Alaska Vegetation Classification
Bank	The sloping land bordering a stream channel that forms the usual boundaries of a channel. The bank has a steeper slope than the bottom of the channel and is usually steeper than the land surrounding the channel.
BT	Bottom-tracking, a method to determine the boat velocity using acoustic reflections off the streambed.
CAM	camera
cfs	cubic feet per second
CGCC	California Geodetic Control Committee
Channel	A natural or artificial watercourse that continuously or intermittently contains water, with definite bed and banks that confine all but overbank stream flows.
CORS	Continually Operating Reference Station
COV	coefficient of variation
Cross-section	A plane across a river or stream channel perpendicular to the direction of water flow.
Depth	Water depth at the measuring point (station).
Devils Canyon	Located at approximately Susitna River Mile (RM) 150-161, Devils Canyon contains four sets of turbulent rapids rated collectively as Class VI. This feature is a partial fish barrier because of high water velocity.
Discharge	The rate of stream flow or the volume of water flowing at a location within a specified time interval.
et al.	"*et alia*"; and the rest
FERC	Federal Energy Regulatory Commission
fps	feet per second
ft	feet
Gaging station	A specific site on a stream where systematic observations of stream flow or other hydrologic data are obtained.
GGA	Geographic position information determined by reference to the Global Positioning System. The position data includes the time, latitude, longitude, and information about the satellite constellation used to reach the position solution.
GIS	Geographic Information System. An integrated collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes.
GPS	Global Positioning System. A system of radio-emitting and -receiving satellites used for determining positions on the earth.
HEC-RAS	hydraulic flow-routing model
Hydrograph	A graph showing stage, flow, velocity, or other property of water with respect to time.
ILP	Integrated Licensing Process
LC	Loop-corrected discharge data

Abbreviation	Definition
Main channel	For habitat classification system: a single dominant main channel. Also, the primary downstream segment of a river, as contrasted to its tributaries.
N/A	not applicable *or* not available
NAVD	North American Vertical Datum, 1988
NEPA	National Environmental Policy Act
No.	number
NSRS	National Spatial Reference System
ºC	degrees Celsius
OPUS	Online Positioning Users Service
PRM	Project River Mile
Project	Susitna-Watana Hydroelectric Project
PT	pressure transducer
OHW	ordinary high water
Q	Hydrological abbreviation for discharge, usually presented as cfs (cubic feet per second) or cms (cubic meters per second). Flow (discharge at a cross-section).
QC	quality assurance, quality control
Reservoir	A body of water, either natural or artificial, that is used to manipulate flow or store water for future use.
River mile	The distance of a point on a river measured in miles from the river's mouth along the low-water channel.
RM	Brailey River Mile(s) for the purpose of this report
RSL	RiverSurveyorLive, data acquisition and processing software.
RTK	Real time kinematic, in reference to a GPS survey method.
s	second
Side channel	Lateral channel with an axis of flow roughly parallel to the mainstem, which is fed by water from the mainstem; a braid of a river with flow appreciably lower than the main channel. Side channel habitat may exist either in well-defined secondary (overflow) channels, or in poorly-defined watercourses flowing through partially submerged gravel bars and islands along the margins of the mainstem.
Slough	A widely used term for wetland environment in a channel or series of shallow lakes where water is stagnant or may flow slowly on a seasonal basis. Also known as a stream distributary or anabranch.
Stage	The distance of the water surface in a river above a known datum.
USGS	DOI, Geological Survey
VTG	Velocity relative to the ground by measurement of the Doppler shift in the satellite carrier phase frequencies, which includes data on direction and speed.
WAAS	Wide Area Augmentation System
Watana Dam	The dam proposed by the Susitna-Watana Hydroelectric project. The approximately 750-foot-high Watana Dam (as measured from sound bedrock) would be located at river mile (RM) 184 on the Susitna River. The dam would block the upstream passage of Chinook salmon, possibly other salmon species, and resident fish that migrate through and otherwise use the proposed Watana Dam site and upstream habitat in the Susitna River and tributaries.
Water slope	Change in water surface elevation per unit distance.

Abbreviation	Definition
WT	water temperature

1. INTRODUCTION

This report provides the results of the 2012 WR-S1 Reservoir and River Flow Routing Model Transect Data Collection Study (Cross-Section Study). The development of hydraulic routing models (ice-free summer and ice-cover winter models) requires horizontal and elevation survey control standards and benchmarks, collection of river cross-section profiles, discharge and stage measurements, descriptions of the river channel characteristics, and gaging stations to collect continuous stage data and supporting meteorological information.

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 (ILP). The Project is located on the Susitna River, an approximately 300 mile-long river in the Southcentral Region of Alaska. The Project's proposed dam site is located at Project River Mile (PRM) 187.2 (RM 184.1). This study provided information to serve as the basis for the 2013–2014 formal study program, for preparing Exhibit E of the License Application, and for use in FERC's National Environmental Policy Act (NEPA) analysis for the Project license.

A hydraulic flow-routing model (HEC-RAS) will be used to simulate unsteady water-surface elevations in response to proposed Project operations during ice-free summer conditions. Additionally, other flow-routing models that simulate ice-cover conditions during winter months will also use the study data and results. The HEC-RAS model will require detailed topographic data in the form of cross sections spaced along the length of the river downstream of the reservoir. In order to accurately simulate unsteady flows, the model will require rating measurements at each cross section, roughness information, and model calibration and verification measurements. The Cross-Section Study objectives included a number of important tasks related to setting up a hydrologic data collection network. A horizontal and vertical GPS survey control network was established to provide a uniform and high quality baseline for all studies to use. The accurate location and common elevation datum of data collection sites is a requirement when water level data will be used across multiple studies and entered into GIS spatial databases and maps. Although data collection to support the river flow routing model is the primary objective of this study, the resulting data will be used by a variety of hydrologic, geomorphic, and instream flow studies. To the extent possible, field data collection will be designed to support all of these studies.

In addition to flow, geometry, and roughness data, continuous water level measurements at a series of gaging stations will be needed to calibrate the model. Water level and temperature data has been and continues to be collected at nine new gaging stations selected to augment five existing USGS stations on the Susitna, Talkeetna, and Chulitna Rivers. An additional four stations are located outside the modeling area (Figure 1-1).

The Cross-Section Study also included data collection at the Susitna River Near Cantwell (No 15291500), a gaging station previously operated by the USGS in the upper Susitna basin to support the proposed Watana Dam Reservoir related studies. Study objectives included the collection of water levels in coordination with the Data Network and Installation and Operations (Network Study) efforts and performing flow measurements to verify the historic rating curves and provide data to compare with other gaging sites downstream of the proposed Watana Dam location. Additionally, the data is being collected in the lower basin to support the Beluga whale study, focusing on the effect of tidal influences. Members of the study team also led water safety training classes to help encourage water safety practices on study teams working on or adjacent to the river.

The study objectives also included coordination with other studies to collect flow, temperature, and stage data at the Susitna River at Susitna Station (discontinued USGS station No. 15294345), and to collect temperature and stage data at two downstream locations within the range of tidal fluctuation. The study also included remote cameras collecting river images at all of the gaging stations outlined above to support the Project's Ice Processes study. This same data also supported the operations and quality assurance of the gaging stations.

Data sets from this study are available from the Alaska Energy Authority (AEA) upon request.

2. STUDY AREA

The Cross-Section Study area covered sites in the upper river starting at Susitna River Near Cantwell Gage (ESS80, prior USGS No. 15291500, PRM 225.0 (RM 223.0)) to the lower river at Susitna River Below Flathorn Lake (ESS10) (Figure 1-1). The main focus of the 2012 study was from the proposed Watana Dam site at PRM 187.2 (RM 184.1) to PRM 80.0 (RM 76.0), which is about seven miles downstream of the Park Highway bridge (Figure 2-1). This portion of the middle and lower river is where the cross-section data collection efforts were concentrated. The reach through Devils Canyon did not involve any field data collection due to safety considerations. The stations in the lower portion of the lower river were installed for support of studies related to beluga whales. The Susitna River near Cantwell gaging station was installed for support of upper basin studies and the studies related to the proposed Watana Dam reservoir studies.

3. METHODS

The study team developed methods and quality assurance (QC) protocols to help insure high quality data products. When applicable, USGS methods and practices were used and USGS staff were consulted about different aspects of the field data collection efforts, especially methods involving the collection of discharge data. QC protocol documents are included in Attachment 1.

3.1. Surveying Methods

A number of different survey methods were used in the study. Global Positioning System (GPS) surveying included both high accuracy methods and the use of hand-held GPS systems for reconnaissance surveying. Optical level surveying was also used in some locations for determining water level elevations and setting up temporary benchmarks at gaging stations.

It is of utmost importance to ensure that precision-critical data be located from a geodetic control network based on a single datum and epoch. In order to insure the integrity of precision-critical study data, strict standards were implemented for the survey of the geodetic control network from which the data locations will be referenced. It was also necessary to implement strict standards for the survey of data locations tied from the control network.

Other aspects of the study will require geographic location, but not to a high level of accuracy. It is important to distinguish between geographic data that is based on the geodetic control network (Static and RTK GPS) and data that is not based on the geodetic control network (hand held GPS systems). A system of data descriptors quality assurance steps was implemented to distinguish whether a particular data point is based on the geodetic control network or from a source of less geodetic accuracy.

Finally, it will be important to ensure that the control network can be repeated in the future with the same standards of accuracy and methodology, based on the identical source of geodetic control (datum, epoch and geoid model).

3.1.1. Standards for GPS Control Networks

The Alaska Society of Professional Land Surveyors (ASPLS) Standards of Practice Manual adopted the California Geodetic Control Committee (CGCC) “Specifications for Geodetic Control Networks Using High-Production GPS Surveying Techniques 1995” as the standard for GPS surveying in Alaska. The specifications outline accuracy standards for various levels of GPS control. The Alaska Department of Transportation and Public Facilities adopted the CGCC standard for Band IV surveys for surveying and mapping services for highways and airports.

The CGCC specifications list four items that are considered paramount for insuring success of a geodetic control project:

1. Elimination or reduction of known and potential systematic error sources
2. Sufficient redundancy to clearly demonstrate the stated accuracy
3. Adequate analysis and data processing
4. Sufficient documentation to allow verification of the results

Careful adherence to the CGCC specifications for GPS surveying ensured that the data used for position modeling was reliable and accurate, and that subsequent work can be reliably based on a common basis of geodetic control.

3.1.2. Static GPS Surveying

Static GPS surveying is the traditional method for relative positioning. Static procedures were used to produce baselines between stationary GPS units. An extended observation period (typically 30 to 120 minutes) through a change in satellite geometry was recorded on one or both carrier frequencies. Post processing utilizes various mathematical models accounting for satellite orbits, ionospheric refraction, and carrier phase ambiguities. The strongest solutions successfully resolved the carrier phase ambiguities and held those values fixed for the final baseline determinations.

3.1.3. Real Time Kinematic (RTK) GPS Surveying

RTK surveying is the method by which a single reference station is used to provide real-time carrier phase corrections by radio link to a roving GPS receiver, providing up to centimeter-level accuracy under ideal conditions. RTK surveys made use of two or more GPS units. At least one unit was set up over a known reference station and remained stationary, while the other (rover) GPS units were moved from station to station. All baselines were produced from the GPS unit occupying a reference station to the rover units. The stationary unit provided real-time corrections which allowed the rover units to resolve integer ambiguities on the fly, providing up to centimeter accuracy under ideal conditions.

Most of the data collected during the course of the project was surveyed using RTK. All RTK data were surveyed from reference stations that are part of the Band IV accuracy level control network. Occupation of the reference control stations was in accordance with the procedures described for static control occupations.

RTK data collected is electronically stored in a “data collector”. Occupation data and point descriptors were entered manually for RTK surveyed points. Each day, the data collector files were downloaded and electronically stored as part of the permanent record. Data collector files contain all of the observation and occupation data for each RTK data point, as well as coordinate data and point descriptors. Coordinates in the data collector files can be adjusted, if required, to reflect different reference station coordinates and/or geoid models used to compute orthometric heights.

Data points, such as TBM elevations, that require a level of accuracy greater than RTK methods can provide, were tied using static GPS observations. Typically those observations were for a minimum period of 15 minutes. The post processed results using single vector solutions over relatively short distances from the reference station provide the desired accuracy for sub-network level control points.

3.1.4. Online Positioning Users Service (OPUS)

The NGS OPUS allows users to submit individual GPS unit data files directly to NGS for automatic processing. Each data file that is submitted is processed with software which computes coordinates for NGS’ Continually Operating Reference Station (CORS) network. The resulting positions are accurate and consistent with other National Spatial Reference System (NSRS) users. This study used OPUS processing as an additional layer of redundancy.

3.1.5. GPS Static Control Network Accuracy, Design, Collection and Processing

3.1.5.1. Accuracy

Static GPS control surveying was conducted according to the standards of accuracy for Band IV surveys. Band IV horizontal and vertical accuracy is defined as a radius of the relative positional error circle of 95% confidence between 0.005 meters and 0.010 meters. Post processing of static GPS observations was constrained to a 95% confidence level for the adjustment process and any adjusted coordinates that failed to meet the criteria for band IV surveys were re-collected.

3.1.5.2. Network Design

The CGCC standards state that space-based measurement systems, such as GPS, are not significantly affected by such factors as network shape or intervisibility. However, GPS-derived orthometric heights are particularly sensitive to the distribution of observations and network constraints.

To meet a network accuracy classification, a GPS project must be connected to sufficiently accurate and well distributed existing control. The project control network was based on a GPS control monument with a published NGS value and verified with ties to two additional monuments with NGS published values. The network was extended up and down the river by constraining multiple vector static observations within a pair of control points at each end. Redundancy was achieved by basing the next constrained control group on the furthest end point of the previous constrained group and conducting at least one static observation on a control point outside the constrained network into the previous day's constrained network. In addition, static observations were conducted across constrained control network groups during the course of the in-stream work whenever possible. Static observations were submitted to OPUS for additional redundant checks. Due to the remote location of the project, the extreme distance from existing CORS network stations and the length of observation times, the OPUS solutions were determined to not be of sufficient accuracy to supersede the highly accurate post-processing results and redundant checks. The OPUS results did serve as a redundant check against systemic error or an individual gross observational error.

3.1.5.3. Data Collection

The key to providing proof of the precision to which a measurement is made is redundancy. Redundancy in GPS surveying is achieved primarily by way of a change in the relative geometry of the satellite constellation. Observations across constrained control groups and ties to the NSRS control network described above are one way to achieve that redundancy. Equally important is the methodology used to document each station occupation.

Each station occupation was independently setup and data collected. Antenna heights were measured, both in feet and in meters, at the beginning and the end of each occupation. A clear photograph/rubbing of the station monument was collected for each station. Notes were prepared for each occupation and included as a minimum:

1. The beginning and ending times for the occupation.
2. The name of the surveyor performing the occupation.
3. The receiver identifier (make, model, serial number).
4. The centering device identifier.
5. All antenna height measurements (in meters and feet).
6. The station identifier (name and/or survey point number).
7. A description of the monument and center mark.
8. Monument photograph/rubbing.

Each station occupation was for a minimum of 120 minutes. Tribracs (centering devices) were calibrated and adjusted prior to the start of the static control network survey.

All control point static GPS observations used a minimum of two vectors. Two base stations continually operated, as nearly as possible, at opposite ends of each day's network control survey area.

3.1.5.4. Data Post-Processing

Static data post-processing was performed according to CGCC guidelines. Post-processing software used least squares adjustment algorithms and provided for atmospheric correction.

GPS post-processing reports were produced for each day's control network group. Post-processing reports show that GPS observations have met the desired specifications Band IV surveys for each vector as well as GPS occupation data for each control point and resulting post-processed and adjusted coordinates.

3.1.6. Differential Leveling

3.1.6.1. Standards for Differential Leveling

Differential leveling for setting gages at streamflow gaging stations were conducted in accordance with USGS Publication "Techniques of Water-Resources Investigations of the United States Geological Survey "Levels at Streamflow Gaging Stations" (Kennedy 1990). Leveling was conducted according to the two leveling classifications, "gaging-station levels" or "ordinary levels", as the requirements determine.

Only "automatic" leveling instruments were used. Automatic levels employ compensators that use gravity to suspend or balance a portion of the instruments optics. In this way, the optical path of light through the instrument is compensated for the vertical axis error before reaching the user's eye. The user should tap the telescope before each reading while looking at the rod to verify that the crosshair returns to its original reading. This method ensures that the compensator is working properly.

3.1.6.2. Leveling Procedure and Documentation

Specific leveling techniques were implemented in order to limit the effects of curvature of the earth, refraction of light, and slight instrument error. Earth curvature, refraction of light and slight instrument error can be mitigated by balancing the distance between the backsight and foresight for each setup of the level. Heat wave interference can be mitigated by conducting leveling operations on an overcast day. Figure 3.1-1 shows the standard leveling procedure and level notes format for gaging-station and ordinary levels (Kennedy 1990).

3.1.6.3. Adjustment of Elevations

Levels were run in a closed circuit that allowed for adjustment by distributing the closure errors as parts of circuits. Each mark on which the leveling rod was read, other than the starting mark, was included in only one circuit and was leveled to both the outward and return paths of only one circuit. The differences in elevation between each pair of adjacent points were meaned to compute each adjusted elevation. Figure 4, leveling, notes and adjustments, in Kennedy, 1990, show the procedure and level adjustment notes format for gaging-station and ordinary levels.

3.1.6.4. Peg Testing and Adjustment of Leveling Instruments

Each level instrument was peg tested and adjusted prior to use in closed circuit level loops. Additional peg tests were required if the leveling instrument was subjected to a shock such as dropping or bumping the instrument. Peg testing consists of driving two stakes about 120 feet apart, setting one of the stakes at a short backsight distance and setting the other stake at a long foresight distance. The level setup was broken and moved to a point a short distance from the foresight stake. The procedure was repeated sitting both stakes. The discrepancy between the sitting distances exaggerated any collimation error in the leveling instrument. The leveling instrument was adjusted and the peg test re-run until the exaggerated level loop closes. Peg tests were documented according to Kennedy, 1990, and kept as part of the permanent record.

Automatic leveling instruments should be adjusted according to the manufacturing specifications for each type of instrument used. This typically involves adjustment of the level bubble and/or the compensator. The method of adjusting the compensator will vary for each manufacturer's product, so specific adjustment information is required to be carried with each automatic level used in the field.

3.1.6.5. Leveling Rods

Level rods for setting gages at streamflow gaging stations are required to be either "Philadelphia", "Chicago" or "Frisco" rods. The two section Philadelphia rod is a very popular general purpose model. It is graduated in hundredths of a foot and is incased in brass sleeves. It is designed for use at distances up to 250 feet. Rod readings of up to thirteen feet can be measured.

Philadelphia rods can be used with a leveling bubble that attaches to the side of the rod. Rod shots must be read with the rod held plumb in order for measurements to accurately reflect the difference in elevation between the benchmark and the instrument crosshair. If a leveling bubble is not available, an accurate reading can be obtained by holding the rod as plumb as possible, and slowly rocking the rod directly toward and directly away from the leveling instrument. The reading is recorded at the lowest point that the crosshair is observed on the rod. The person operating the leveling instrument can check whether the rod is plumb by checking the rod against the vertical crosshair of the instrument, and direct the rod holder to adjust the rod until it is vertical.

Great care should be taken to insure that the rod is clean, particularly at the bottom where it makes contact with the mark being measured. When rod heights greater than seven feet are required, great care must be taken to fully extend the rod in order to obtain accurate measurements. The rod should be transported in a fabric cover and nothing should be placed on the rod during transportation that could scratch or bend the rod. Any rod that has the graduated marks partially or fully obscured or rubbed off should be replaced.

Rod checking and operation will be in accordance with the requirements outlined in Kennedy, 1990.

3.2. Hydrologic Data Collection

This section will discuss the general measurements of water levels, cross-section profiles, Doppler methods, and water-slope determination. Channel roughness determinations were made through the hydraulic modeling efforts reporting the flow-routing model technical memorandum. Field data and photographs of cross-sections from this study were also used when needed.

3.2.1. Transect Cross-Section Profiles

Cross-section profiles were measured using a combination of RTK surveying methods. Baselines were established and permanent monuments (rebar with aluminum cap or cemented brass tablet) were set at both ends of each cross-section location. RTK profiles were taken in the upland portion (from edge of water to edge of vegetation typically) and additional water surface elevations were taken approximately 200 feet upstream and downstream of the baseline. The goal of the cross-section measurements was to measure up to the 90% exceedance discharge for the Susitna River at Gold Creek, which is approximately 25,000 cfs. The lead river hydrographer made field determinations of the upper elevation boundary based on flow conditions at the Susitna River at Gold Creek gage. River bottom profiles were measured with the ADCP unit, making multiple tracks back and forth across the channel. Positions of the ADCP observations were tracked using RTK and stored in ASCII files. These files were imported into AutoCAD, along with the RTK upland survey data. A topographic surface was then created and a line profile was generated along the cross-section baseline representing the channel cross-section profile. This data was then translated into both latitude and longitude and state-plane coordinates.

90% exceedance Q for Gold Greek is ~25K cfs

3.2.2. Manual Water-Level Measurements

Water level measurements were made primarily by RTK surveying or level-loop surveying methods. Staff gages were evaluated for measuring water levels on the main channel of the Susitna River and were eliminated for the following reasons;

1. Trees and woody debris in the river would create too much damage to staff plates
2. Two to four staff plates at each section would be required to cover the range of stage changes, creating a boating hazard at each location
3. Unstable banks and moving riverbed conditions did not make staff plates a practical solution in most locations

The use of staff plates should still be considered in sloughs, creeks and other areas that do not have the above problems. Field crews took into account wave motion of the water surface and determined an average location to hold survey rods for determining the water surface location at each measurement location.

3.2.3. ADCP Discharge Measurements

Discharge measurements were performed using a Sontek M9 ADCP deployed from a motorized cataraft. The ADCP was mounted in a plastic monohull to prevent cavitation at high flow velocities. Pivoting struts allow the instrument’s pitch to vary independent of the cataraft, and roll is minimized by the cataraft’s small depth to beam ratio. The slight downpressure of the struts maintains acoustic contact at high flow velocities, but requires a tether to prevent the monohull from diving in standing waves (Figure 3.2-1).

The forward position of the ADCP and computer interface allows the hydrographer to monitor depth, velocity, measurement duration, and data quality while simultaneously navigating the boat. A sole operator permits a lighter boat and motor than that required for 2 or more people. This allows navigation in shallower water, so that unmeasured bank sections usually comprise a negligible proportion of the total discharge. Safety was provided by an accompanying support/rescue craft.

Although the cataraft frame and accessories are comprised of non-ferrous materials, the outboard motor (85 lbs.) is largely steel. The motor is located approximately 10 feet aft of the ADCP.

Beginning with a description of measurement procedures, the following sections provide results of data quality evaluations currently required by USGS (OSW 2012c). These evaluations are unique to ADCP measurements from a moving boat; different evaluations would be appropriate for current meter measurements or ADCP measurements through ice.

Relying on the Doppler principle, ADCPs measure water velocity using acoustic reflections from suspended particles. In order to calculate discharge, the instrument velocity is also required. Most ADCPs use bottom-tracking (BT) to determine the instrument velocity using acoustic reflections off the streambed. However, BT-based discharge measurements can be biased low by moving bedload. In this case, the instrument velocity can be measured using GPS methods, or BT-based discharge measurements can be corrected using moving bed tests. Both of these alternatives require accurate heading information, either from an internal compass or an external heading device.

As an option, the Sontek M9 includes a GPS receiver that accepts differential corrections from a real-time kinematic (RTK) base station or from the Federal Aviation Administration's Wide Area Augmentation System (WAAS). Whereas WAAS precision is within 1 meter, the precision of RTK measurements can be within centimeters. Although GPS transmissions include two data strings used to compute discharge (GGA and VTG), differential corrections apply only to GGA positions. Because of the improved precision provided by the WAAS and RTK corrections, discharge data were processed using only GGA positions. VTG positions are recorded in the data file for each transect, however.

The Sontek M9 uses Sontek's RiverSurveyorLive (RSL) software for data acquisition and processing. Most of the measurements were acquired using RSL v. 3.01 and firmware v. 2.00, dated October 2011. The RSL software includes the USGS LC program for analysis of loop moving bed tests. In response to a July 2012 revision of LC (v. 4.04), Sontek released RSL v. 3.50 and firmware v. 3.00 in August 2012. To correct errors resulting from the outdated RSL v. 3.01 software, all of the data were post-processed using RSL v. 3.50.

In August 2012, the USGS issued Best Practice Recommendations identifying compass calibration issues for late-generation ADCPs including the Sontek M9/S5 and the Teledyne/RDI RiverRay (OSW 2012b; 2012d). Specifically, the algorithms in RiverSurveyorLive were shown to be unreliable for creating accurate compass calibrations. The Recommendations conclude that the calibration score cannot be used to evaluate compass accuracy, and "the best that can be done is to follow good calibration procedures and then carefully observe the collected data for potential compass errors".

Including compass calibrations, discharge measurements were performed in accordance with current USGS guidance (Mueller and Wagner 2009; OSW 2012c). This includes:

- pre-season factory instrument checks
- software and firmware upgrades
- periodic field instrument checks
- daily and site-specific compass calibrations, two complete rotations, 1-2 minutes
- site-specific loop moving bed tests (3 minute minimum)
- reciprocal transects comprising at least 12 minutes of exposure time
- site-specific velocity profile extrapolations
- office review and evaluation

3.2.3.1. ADCP Data Quality

The quality of ADCP measurements was evaluated using procedures outlined in the USGS Hydroacoustics webinar ***Review and Rating of Moving-Boat ADCP Q Measurements*** (OSW 2012c). This webinar recommends procedures for assigning four qualitative ratings to ADCP data: Excellent, Good, Fair, and Poor. These ratings correspond to categories of uncertainty ranging from 0-2%, 2-5%, 5-8%, and over 8%, respectively. Because some data quality metrics are non-quantitative, the rating categories are semi-qualitative in nature.

Although much of the supporting data was compiled by the field hydrographer, the final ratings were assigned by an independent reviewer on a separate AEA Study Team. Discharge measurement results, including the final ratings, are summarized on Attachment 3. Because the same evaluations were performed on over 200 measurements, they are summarized below following procedures outlined in current USGS guidance (Mueller and Wagner 2009; OSW 2012a, 2012c).

3.2.3.2. Measurement Variation and Base Uncertainty

The four discharge rating categories correspond to levels of uncertainty that include both flow variability and measurement error. In accordance with USGS guidance, the ratings were assigned using both qualitative and quantitative information. The coefficient of variation (COV) represents a fundamental data quality metric, defined as the standard deviation divided by the mean of replicate transects. As described by USGS (OSW 2012c), the 95 percent uncertainty of a measurement can be approximated as the COV (in percent) multiplied by a factor related to the number of transects (Table 3.2-1), plus 0.5 percent for systematic errors. If additional uncertainty is indicated by moving bed tests or data quality issues, the 95 percent uncertainty value should be increased. The final 95 percent uncertainty values can then be used to rate the measurement as either Excellent (0-2%), Good (2-5%), Fair (5-8%) or Poor (over 8%).

Calculated 95 percent uncertainty values are summarized on Attachment 3. These values include the base uncertainty described above, plus additional uncertainty for measurements affected by moving bedload. Due to a slight negative bias between GGA and both BT and LC results, results were compared for each measurement and the highest value was reported.

3.2.3.3. Compass Calibration

In August 2012, the USGS issued Best Practice Recommendations for late-generation ADCPs including the Sontek M9/S5 and the Teledyne/RDI RiverRay (OSW 2012b; 2012d). Both of these instruments allow automatic bin sizing that has been shown to be an important factor in reducing measurement uncertainty (Garcia et al. 2012). The recommendations conclude that the Sontek M9's calibration score cannot be used to evaluate compass accuracy, and "the best that can be done is to follow good calibration procedures and then carefully observe the collected data for potential compass errors".

During an initial instrument check at USGS Gaging Station No. 15281000 (Knik River near Palmer), failing calibration scores were obtained for both a newly-manufactured M9 (serial no. 3061) and a one year-old model (serial no. 2837). Despite these results, agreement between the two instruments was within 2 percent, and agreement with the rating was within 4 percent. Based on subsequent discussions with Sontek, calibration scores were disregarded if the collected data appeared unaffected by compass errors. According to USGS (OSW 2012a), common indications of compass error include directional bias in ship tracks or transect discharges, and downstream closure of loop moving bed tests.

In an effort to resolve calibration issues, compass calibrations were performed with the ADCP both on-board and removed from the boat. In both cases, the ADCP was rotated through at least 720 degrees in a 1-2 minute interval. Relatively low pitch and roll was maintained during the calibrations, similar to that during normal boat operations.

The first 35 measurements were performed after site-specific compass calibrations with the ADCP mounted on the boat. All of the calibrations exhibited failing scores, but successful loop tests and low directional biases initially indicated normal compass operation. Downstream loop test closure occurred on the 13th measurement, and recurred for 8 of the next 22 measurements. Downstream loop closures persisted during subsequent measurements using off-boat compass calibrations, but the overall measurement quality improved (Attachment 3).

3.2.3.4. Constant and Variable Heading Errors

If the local magnetic declination differs from that entered in an ADCP's data acquisition software, a heading error will be manifested as directional disparities in GPS ship tracks and computed discharges. This effect can be reduced by adjusting the magnetic declination until directional disparity in GPS discharge reaches a minimum, corresponding to the minimum COV for reciprocal transects (Figure 3.2-2). In this report, the difference between the declination obtained from a geomagnetic model (e.g., NOAA 2012) and a local value yielding the minimum COV for reciprocal GPS transects is termed ***constant heading error***.

Constant heading errors can be caused by magnetic interference from stationary objects like bridges, or local anomalies in the earth's magnetic field. Provided that measurements are comprised of reciprocal transects, the effect of constant heading errors can be removed by adjusting the declination until the GGA COV reaches a minimum. Constant heading errors do not affect the results of loop moving bed tests (Mueller and Wagner 2006).

Another type of heading error can be caused by interference from magnetic objects on the boat. This type of error varies with heading, and is modeled using sinusoidal functions (Mueller and Wagner 2006). In this report, the latter type of error is termed ***variable heading error***. Variable heading errors can cause both upstream and downstream loop closure errors (Mueller and Wagner 2006). Although downstream loop closures are easily identified, upstream loop closure errors are difficult to distinguish from actual bed movement.

To evaluate the effect of heading errors, the accuracy of 2012 stationary-bed measurements was compared against 63 stationary-bed measurements from the United States, Canada, and New Zealand (Wagner and Mueller 2011). These data were found to be of sufficient quality to support the use of both GGA and VTG positioning for discharge measurements. By excluding RTK measurements, their results support the use of WAAS-corrected GGA positions, thereby eliminating the need for a local base station.

For their dataset, Wagner and Mueller computed the accuracy of GGA-based discharge measurements as the percent difference between bottom-track and GGA-based discharge values ([GGA-BT]/BT). They computed [GGA-BT]/BT for both individual transects and measurements comprised of multiple transects. The latter analysis exhibited better precision and eliminated spatial bias inherent in the data.

Figure 3.2-3 compares the accuracy of Wagner and Mueller's (2011) results with 2012 measurements where loop tests indicated stationary bed conditions. Excluding 1 low outlier for a small, backwatered channel, the average 2012 bias is equivalent to Wagner and Mueller's (0.52 percent). Wagner and Mueller used these results to show that the GGA and BT results are not significantly different, thereby supporting the use of GGA positioning. By analogy with Wagner and Mueller's results, the accuracy of the 2012 GGA results for stationary bed conditions appears acceptable.

A similar analysis was performed for 2012 measurements with upstream loop closures indicating moving bed conditions. Figure 3.2-4 displays the accuracy of 2012 loop-corrected (LC) discharge data, calculated as [GGA-LC]/LC. Two low outliers measured during high-flow conditions showed GGA discharges well below their corresponding BT discharges. Although this situation is expected for a small proportion of measurements, it is most likely to occur at low bed velocities. Because the two outliers yielded moving bed velocities within the top quintile of all measurements, they are presumed to reflect upstream loop closure errors. The remaining sample population exhibits a distribution similar to Mueller and Wagner's, with a slightly lower mean (-0.87 percent). This could reflect either additional upstream loop closures or an exaggeration of the slight negative bias between GGA and BT results (Figure 3.2-3). To account for this additional uncertainty, the 95% uncertainty values shown on Attachment 3 were increased by 0.5 percent for all measurements affected by moving bedload.

Using flow direction as an indicator of the average boat orientation, Figure 3.2-5 suggests that constant heading errors are related to the boat orientation. This indicates magnetic interference from an on- board source, most likely the outboard motor. It is clear from Figure 3.2-5 that on-board compass calibrations were not effective at eliminating this effect. Although the data show that some constant heading errors can be attributed to fixed objects (e.g., the Gold Creek railroad bridge), it appears that most heading errors are only "constant" to the extent that changes in boat orientation are small relative to the average boat orientation. Evidently, changes in boat orientation were small enough to allow accurate loop closures for the 117 stationary and moving bed measurements shown on Figures 3.2-3 and 3.2-4. Although a detailed analysis of boat orientations has not been performed, it appears that larger variations in boat orientation were responsible for the 39 downstream loop closures.

For sites with stationary and upstream loop closures (except as noted above), GGA and LC accuracy appears acceptable and is unrelated to the magnitude of constant heading errors (Figure 3.2-6). LC results are invalid for sites with downstream loop closures, where GGA results are consistently lower than BT results (Figure 3.2-7). At these sites, BT results must qualified for potential moving bed effects.

3.2.3.5. Moving Bed Tests

Although BT-based discharge measurements are not affected by heading errors, they can be biased low by moving bedload. In this case, discharge can be measured using GPS positioning, or BT-based discharge measurements can be corrected using moving bed tests. To allow the use of BT measurements, moving bed tests were performed at most cross sections.

Moving bed bias can be evaluated using either stationary or loop moving bed tests. For this study, loop tests were selected because they provide a measure of the average bed velocity across the width of the channel. Stationary moving bed tests measure the bed velocity at individual points, requiring averaging or extrapolation across the remainder of the channel.

Whereas loop moving bed tests require accurate compass headings, stationary moving bed tests do not. Due to the recent identification of compass calibration problems with late-generation ADCPs, USGS currently recommends stationary moving bed tests due to their more consistent reliability than loop moving bed tests (OSW 2012b,d).

Loop tests are performed by recording a loop-shaped transect beginning at marked location (typically a buoy) near one bank, traversing the channel, and returning to the original starting point. If there is moving bedload, the BT shiptrack will be displaced so that the transect endpoint is located upstream of the starting point. The USGS LC program uses these data to compute the corrected discharge using the starting point displacement and the measured velocity profile.

Although loop tests were planned for every measurement, high flow velocities during the first three measurements caused diving of the ADCP monohull in standing waves. Initially, this situation was remedied by performing diagonal transects with lower boat-to-water velocities. Although this technique was successful, it precluded loop tests due to the inability to return to the original starting point. Eventually, a tether system was developed to prevent diving of the ADCP (Figure 3.2-1). After the third measurement, loop tests were performed at all of the main channel crossings except where fast, shallow water required walking of the cataraft. In these situations it was not possible to maintain the uniform boat speed and orientation necessary for an accurate loop test.

A total of 178 loop tests were performed, of which 71 tests yielded upstream loop closures, 38 tests yielded downstream loop closures, and 51 tests indicated stationary bed conditions (bed velocity < 0.04 fps). Eight loop tests were invalid due to lost bottom track or apparent changes in flow direction, and 10 tests did not warrant loop corrections due to bed velocities less than 1 percent of the mean flow velocity. A rose diagram illustrates the proportion of upstream vs. downstream loop closures (Figure 3.2-8).

As shown by Figure 3.2-5, it appears that compass headings were affected by magnetic interference from an on-board source, most likely the outboard motor. The 38 downstream loop closures and two erroneous upstream loop closures (Figure 3.2-4) were probably caused by variable heading errors as the boat changed orientation during the loop. Changes in boat orientation were apparently small enough that 69 upstream loop closures and 51 stationary loop tests yielded acceptable results. Due to swift current and the long duration of most loops (average = 307 seconds), only slight changes in ferry angle were needed for most transects. Larger changes in boat orientation were required above and below islands, in eddies, and across slack channels.

Plots of bed velocities vs. river mile show that moving bed conditions were predominant above PRM 143 (RM 139.4) during late June, when Gold Creek flows were above 33,000 cfs (Figure 3.2-9). Moving bed conditions also predominated below the Chulitna confluence throughout the summer and fall.

As shown by Figure 3.2-7, GGA-based discharge measurements with invalid loop closures show a large negative bias relative to BT-based measurements. This indicates that these GGA data are affected by variable heading errors and cannot be used. As a result, discharge values for measurements with invalid loop closures must rely on BT positioning, qualified for moving bed bias. To assess the amount of moving bed bias, bed velocities at sites without accurate loop tests were estimated by interpolating between adjacent sites (Figure 3.2-9). Using the empirical relationship shown on Figure 3.2-10, interpolated bed velocities were used to calculate estimated moving bed biases for sites without valid loop closures. The calculated moving bed biases are shown on Attachment 3, ranging from zero to 4.7 percent. Considering the variance of adjacent bed velocities (Figure 3.2-9), an additional 1 percent of uncertainty was added for measurements with calculated moving bed biases.

For sites with multiple channels, the highest bed velocity was plotted on Figure 3.2-9, typically corresponding to the main (largest) largest channel. Loop tests were omitted for some side channels containing less than 10 percent of the total discharge. If accurate loop tests were not available for side channels containing more than 10 percent of the total discharge, moving bed bias was estimated using main channel values, either measured or calculated.

3.2.3.6. ADCP Check Measurements

ADCP check measurements were performed prior to the field program at USGS Gaging Station No. 15281000 (Knik River near Palmer), and during each field trip at USGS Gaging Station No. 15292000 (Susitna River at Gold Creek). Field measurements were compared against online discharge data obtained through the National Water Information System. These data are provisional pending review and approval by USGS. Provisional data are commonly revised due to rating shifts, transducer movement, and ice affects.

During the initial Knik River check measurement, agreement between the two ADCPs was within 2 percent, and agreement with preliminary online discharge values was within 4 percent (Table 3.2-2). June and August check measurements on the Susitna River at Gold Creek were 6 to 8 percent lower than the provisional online values, but the September check measurement was within 1.1 percent. Although the August and September online discharge values are identical, the surveyed river stage in August was 0.25 feet lower than September. This could explain the apparent low bias of the August check measurements, but review of the provisional data is needed.

3.2.3.7. Extrapolation Settings

Due to signal interference, ADCPs cannot measure velocities near the surface or in close proximity to the streambed. As a result, velocities in these areas are estimated by extrapolation of the measured velocity profile. By default, RiverSurveyorLive uses a power law fit to estimate velocities in these areas. As shown on Attachment 4, combined top and bottom estimates ranged from 19 and 47 percent of measured flows. Because these areas comprise a large proportion of the total flow, the extrapolation settings were evaluated further using the USGS program Extrap (OSW 2012e).

Processing of the 872 transects summarized on Attachment 3 revealed that most velocity profiles approach constant or decreasing values toward the water surface, rather than increasing velocities as predicted by the power law (Figure 3.2-11). As a result, the “constant” extrapolation method was typically selected in Extrap for calculating near-surface velocities. Similarly, the “no-slip” extrapolation method typically provided a better fit for near-bottom velocities. Using Extrap, the appropriate extrapolation settings were selected for each measurement, and results were used to compute revised discharge values in RiverSurveyorLive. Extrapolation settings for each measurement are summarized on Attachment 3.

3.2.3.8. Edge Estimates

Because ADCPs require a minimum water depth for velocity measurement (termed the blanking distance), the discharge near both banks must be estimated based on the adjacent flow velocity. In accordance with USGS protocols (Mueller and Wagner 2009), edge estimates require at least 10 stationary velocity measurements (termed samples) containing at least two valid “bins” beneath the ADCP. For ADCPs with large blanking distances or vessels with deep drafts, edge estimates can be a significant potential source of error. However, the Sontek M9 can measure two valid bins in depths ranging from 0.7 to 1.3 feet of water. Because these depths can be readily navigated with the solo cataraft, 2012 edge estimates comprised a minor proportion of the total discharge.

Excluding one channel with a near-shore obstacle (RM223, 6/14/12), the maximum edge estimate was less than 1 percent of the total discharge for any cross section, and sum of the left and right edge estimates averaged less than 0.1 percent of the total cross-sectional discharge. Because the magnitude of these estimates is smaller than the precision of measured flows (Figures 3.2-3 and 3.2-4), 2012 edge estimates are not a significant source of error. Nevertheless, edge estimates were reviewed during post-processing to confirm that valid velocity measurements were obtained, and that bank distances matched those recorded in the field book. Bank distances less than 10 feet were measured using a graduated cataraft oar, and bank distances over 10 feet were measured with a laser rangefinder.

3.2.3.9. Transect Duration and Exposure Time

Current USGS protocol requires that measurements consist of reciprocal transects with a minimum combined duration of at least 720 seconds (OSW 2012a). This requirement was achieved for 146 of the 154 main channel measurements (Attachment 3). Another 5 main channel measurements were shorter (668 to 716 seconds), but were co-located with side channel measurements that increased the combined measurement duration to over 1,100 seconds. Similarly, 27 side channel measurements ranged from 416 to 716 seconds, but were paired with main channel measurements that increased the total duration to over 1,000 seconds. Three single-channel measurements with durations less than 720 seconds are highlighted on Attachment 3.

Additional USGS guidance recommends a minimum transect duration of 150 samples. This goal was achieved for 855 of the 872 transects. Shorter transects (104 to 148 samples) were necessary in smaller side channels because of their limited widths. Because of their relatively low discharge, short transect durations in small side channels are not expected to significantly affect the total discharge for multi-channel measurements.

3.2.3.10. Invalid Samples and Bad Bottom Tracking

Incomplete velocity profiles can result from loss of communication with the ADCP or signal interference. No communication problems were encountered during data acquisition, and no interference from turbulence, shear, or high suspended sediment concentrations was identified. However, loss of bottom-track positioning occurred during several loop tests, and the associated discharge measurements showed poor bottom track strength (Attachment 3). In these cases, discharge measurements relied on GGA positioning.

3.2.3.11. System Tests

Instrument diagnostic checks were performed daily from RiverSurveyorLive, and results are saved with the associated measurement files. No anomalous system test results were obtained.

3.2.3.12. Temperature Checks

Water temperatures were measured at each cross section with a digital thermometer. No discrepancies were observed during comparison of manual temperature measurements against those recorded by the ADCP.

3.2.4. Water Slope Measurements

Water slope measurements were made at each cross-section for each discharge measurement period. In some cases, additional water slope measurements were made at sections where discharge measurements were not made. The water surface elevations were generally measured generally by RTK surveying; although in some cases water surface elevations were measured by level-loop surveying. The RTK survey method was faster and allowed a greater number of measurements per day. In general water levels were collected on both banks, upstream and downstream of each section. The distances between observations and water slopes were calculated for each set of measurements. The location of all points, PRMs, water elevations, and slopes were reported in printable and GIS data formats.

3.2.5. Continuous Stage Hydrographs at Gaging Stations

Thirteen gaging stations were installed and operated for the objectives of this study. Each gaging station incorporated a Campbell Scientific Inc. CR1000 data acquisition and control logger, 2 CS450 pressure transducers that measure water pressure and water temperature, and one GWS-YSI air temperature sensor. A gaging station metadata standard document is included in Attachment 2. Data was recorded at 15 minutes intervals and saved in data tables on the logger. Each station is on a radio-telemetry network and data is retrieved on an hourly collection interval. Each gaging station has established vertical datum benchmarks to allow the surveying of manual water level measurements through either level-loop of RTK methods. The water levels allow the conversion of the pressure transducer data to surface-water elevation in Project vertical datum standards.

Manual water-level measurements were collected at stations during the summer to help determine offsets for the continuous data and validate pressure transducer readings. The continuous data and manual water level measurements were processed in Aquarius Workstation to help apply elevation shifts and evaluate the continuous data.

Graphical plots were made for each gaging station and compared with nearby stations, both upstream and downstream as part of the QC process for the data (Figure 3.2-12) (Attachment1).

3.2.6. Other Transect Data

3.2.6.1. Channel Roughness

Field observations and photos at each transect were recorded to support estimates of channel roughness. Calculated channel roughness values were a product of the open-water flow routing model (see Section 4.4.1 of the Open-water Flow Routing report (R2 2013). Recorded field observations and photos were used to help calibrate the values calculated using the open-water flow routing model.

3.2.6.2. Vegetation Descriptions

Vegetation descriptions were developed from photographs taken at each section. In general there is at least one set of photographs at each section looking upstream, downstream, and across the channel. Information on vegetation types (Viereck et al. 1992) was used in classifying vegetation at each cross-section. An example cross-section photograph is shown in Figure 3.2-13.

3.3. Data Analysis

The 2012 study period resulted in three measurement campaigns that produced approximately 170 pairs of stage and discharge data pairs. Each section measured had one to three measurement points, plus a measured thalweg point. These data are used to help develop rating curves (stage versus discharge) for the cross-sections and gaging stations. Plots were made to help show the initial location of rating curve points. Additional data will need to be collected to establish full rating curve relationships. The lack of low flow measurements at most locations limits the development of full rating curves from the 2012 field measurements. An example is shown for PRM 187.2 (RM 184.1) in Figure 3.3-1.

3.4. Deviations from Study Plan

The following deviations from the Cross-Section Scope of Work cover many of the field and hydrology conditions encountered during the 2012 open-water season. No major objectives of the study were impacted except for the lack of low-flow conditions during the summer.

- The general high flow conditions in 2012 resulted in few low flow measurements being made. The cross-sections were measured during three field trips intended to capture high-flow (28,000 cfs), medium-flow (16,000 cfs), and low-flow (8,000 cfs) conditions corresponding to the USGS gage station at Gold Creek (No 15292000). The first two trips were successful at capturing high-flow and medium-flow conditions during late June-early July and August, respectively. However, the low-flow trip that began on September 14 was interrupted by a 25-year flood event that required evacuation of the field team on September 20. Work resumed on September 29, but was suspended on October 6 when a second late fall storm resulted in unseasonably high flows. A final attempt commenced on October 15, but abundant river ice and slush pans precluded accurate flow measurements. The development of rating curves for the gaging stations and cross-sections will require additional flow measurement in subsequent years. This deviation resulted in fewer low flow measurements which limited the determination of rating curves for sections.

- The original field plan identified the need for cross section and historic image georeferencing. The development of these products was not part of the study scope, but the study planned on using them in the early planning. These GIS products were not produced in time to use for the study activities. This generated a set of river mile conventions, termed Brailey River Miles (RM) for this study. The final Project River Miles (PRM) did not become available until the end of 2012, so all study data products were converted over to the PRM designations, and cross-indexes were made between the study RMs and PRMs. This deviation did not impact the final data products, but resulted in additional time to complete them.
- Measurements of sections results from the high water levels and flooding during September, which was also intended to be the low-flow measurement campaign. This broke the trip up into two segments. The second portion being in October, when another flood event was encountered and the field crew had to stop work and then try and restart field measurements a third time. By this time the amount of river ice developing resulted in poor quality data and the 2012 field measurement campaign series was ended. This deviation resulted in fewer low flow measurements which limited the determination of rating curves for sections.
- The September flooding events resulted in the potential for channel changes, so 10 additional cross-sections were re-measured to document potential channel changes due to the flooding. This deviation did not impact the creation of final data sets, but added data to help evaluate the impacts of the September flooding.
- The original study scope did not include permitting, which became a requirement to help conduct the planned activities for the summer. This deviation did not impact data products, but did require more staff resources to help keep the project timeline objectives.
- A primary deviation from the study plan was the configuration of field crews to use RTK survey methods for all measurement trips and issues related to flooding and high water levels in complex channel sections. The number of channels at most cross-sections, water velocities and various water hazards limited the number of sections that could be measured downstream of the Chulitna River and Susitna River confluence. In some cases there were up to nine channels in one cross section. An average of 4 channels can be measured in a typical day, under ideal conditions. Level Loop surveying was also determined to be a limiting factor in the field and would have resulted in significantly less sections being measured. In many cases, this was due to the steep or loose bank conditions along the river. The switch to RTK surveying methods allowed the survey crew to keep up with the pace of the river gaging crew and to have the water safety field crew focus on the river hydrographer, who otherwise would have been working solo and without adequate safety oversight. This deviation in field methods was made to ensure the transect data needed for flow routing model development was achievable within the study period and to help meet the FERC evaluation process, but the final field approach

helped ensure the required data was collected under the challenging field conditions in a safe and efficient manner.

4. RESULTS

All the major objectives of the study were achieved. A number of cross sections were not measured due to the field conditions, flood events and onset of winter ice conditions in the river. These reductions in the number of sections and measurements did not result in any significant loss of study objectives. Most of these sections were in the portion of the lower river below the confluence of the Chulitna River (PRM 102 (RM 98.5)) to PRM 80 (RM 76), about 8 miles below the Parks Highway Bridge. The loss of measurements would affect the simulation accuracy of Lower River water levels with the Version 1 of the flow routing model; but initial model results appear consistent with HEC-ResSim modeling results (see January 2013 Open-water Flow Routing Technical Memorandum). Additional sections and discharge measurements at gaging stations and select cross sections in 2013 and 2014 will help refine and improve subsequent versions of the flow routing model.

4.1. Survey Control Network and Results

The survey control network was established and is shown in Figure 4.1-1, with control point stations listed in Table 4.1-1. The control network extends from the upper portion of the proposed reservoir down to the lower portion of the lower Susitna River. Geodetic coordinates, benchmark descriptions and photographs were produced and also provided for the Project geospatial databases.

As part of the 2013 work program it is recommended that additional control points be added to the project control network. Project control was extended to the lower part of the river for specific use at gaging stations. Large gaps between control points exist in that portion of the project area. Should RTK surveying be required throughout the lower portion of the river, it will be necessary to increase the density of the control network to support studies in this river segment.

The standards for GPS control networks in use for this project require redundant checks of the control points to provide verification of positional accuracy. This is particularly important when the control points have gone through a series of winter freeze thaw cycles. During the initial 2012 control network survey, several brass tablets were cemented into rock in locations where it was practical. These brass tablets are certain to be stable through the winter freeze thaw cycles, providing anchors in between adjacent control points. If brass tablets cemented into rock can be installed in additional strategic locations throughout the project corridor, it will make it possible to verify the positional accuracy of the control points that are subject to freeze thaw movement without having to initiate a major resurvey of the entire network.

The original control network was designed to provide RTK radio link between the base GPS receiver and the rover GPS receivers in all areas of the project corridor. During the 2012 season there were several locations within the project corridor where it was discovered that radio linkage was difficult. The study program would benefit from placement of additional control points during the resurvey/redundant verification of the network control.

4.2. Hydrologic Data Collection

The following sections describe the results of the hydrologic data collection activities for the study in 2012. The use of this data for modeling and other interpretation will primarily be covered by future studies. The open-water season measurements were broken down into three measurement campaigns. The study intent was to collect a series of high flow observations in June and July, then moderate flow observations in August and then low flow observations in September. Figure 4.2-1 illustrates the three time campaigns and the actual flow conditions encountered during 2012, using the Susitna River at Gold Creek as an index station for understanding general flow conditions. Table 4.2-1 listed the gaging stations established for the study. Table 4.2-2 lists the cross-sections and discharge values measured during the 2012 open-water season. The series of maps shown in Figures 4.2-2 through 4.2-19 shows the location of the measured cross sections, gaging stations and GPS control network survey points along the Susitna River from approximately PRM187.2 (RM 184.1) to PRM 80 (RM 76.0).

4.2.1. Transect Cross-Section Profiles

88 transect profiles were measured from PRM 187.2 (RM 184.1) (proposed Watana Dam site) to PRM 80 (RM 76.0) (about 8 miles downstream of the Park Highway Bridge) during the 2012 open water season. Details of the cross sections are reported in the open-water flow routing model (see Section 5.4 of the Open-water Flow Routing report (R2 2013).

4.2.2. Water-Level Measurements

Water level measurements were primarily made by RTK surveying and in some cases level-lop surveying. Data collected at the gaging stations typically used level-loop survey methods. Data collected at cross sections typically used RTK survey methods. The water level measurements went through a QC process (Attachment 1) and were used in the interpretation of gaging station continuous water level data (Figure 3.2-13) and for the development of rating curve development data (Figure 3.3-1).

4.2.3. Discharge Measurements

During the 2012 open-water season, a total of 214 discharge measurements were performed at 89 cross sections. This includes 88 cross-sections between PRM187.2 (RM 184.1)and PRM 80 (RM 76.0), plus some additional locations outside of the modeling domain (PRM 225.0 (RM 223.0), and QC measurements at various locations). The river transect at PRM 101.4 (RM 100.4), cross-section measurements were made, but no final discharge measurements that passed QC evaluation.

The data collection approach was to measure at least one discharge at each cross section transect channel. Subsequent measurement campaigns were to measure discharges at an intermediate and low flow condition. Where closely spaced channels could have flows adequately estimated for model simulations objectives, about a third of the transects were estimated to only need the single discharge measurement. The exact number of transects requiring more than one measurement were identified by field hydrographers in conjunction with the flow-routing modelers. There were not a specific number of water level/discharge measurement pairs targeted for the 2012 open water season. Water levels were collected at all cross-sections during discharge measurement campaigns, except during the September discharge measurement campaign which was interrupted by two flood events (damaging RTK GPS equipment) and onset of winter icing conditions. Discharge was measured using a Sontek M9 acoustic Doppler current profiler (ADCP) following USGS guidance published in January 2012 (OSW 2012a). Although over 90 percent of the measurements are rated as either Excellent or Good (0-5% uncertainty), about 8 percent of the measurements are rated as Fair or Poor (5-10% uncertainty). These ratings are preliminary pending technical review by an independent AEA contractor.

The primary data quality issue involves heading errors caused by inaccurate compass calibration. As outlined in an August 2012 USGS ***Best Practice Recommendation*** (OSW 2012b), the inaccurate calibrations are related to unreliable scores produced by Sontek's data acquisition software. The Recommendations conclude that "the calibration score cannot be used to evaluate compass accuracy, and "the best that can be done is to follow good calibration procedures and then carefully observe the collected data for potential compass errors".

In addition to measuring the water velocity, ADCPs must also measure the boat velocity in order to calculate discharge. Most ADCPs use bottom-tracking (BT) to determine the boat velocity using acoustic reflections off the streambed. However, BT-based discharge measurements can be biased low by moving bedload. In this case, the boat velocity can be measured using GPS methods, or BT-based discharge measurements can be corrected based on moving bed tests. Both of these options require an accurate compass, however.

A total of 178 loop moving bed tests were performed, of which 71 tests yielded upstream loop closures, 38 tests yielded downstream loop closures, and 51 tests indicated stationary bed conditions. The 71 upstream loop closures indicated moving bed conditions resulting in loop-corrected (LC) discharges up to 5.7 percent greater than their corresponding BT discharges. The 38 downstream loop closures indicate compass errors rendering GPS-based discharge results invalid. Although the corresponding BT results are potentially biased low, the bias was quantified using bed velocities from nearby sites. Including uncertainty for the estimated bias and other moving bed effects, the total uncertainty was used to qualify BT results for sites with downstream loop closures.

All ADCP data was post-processed following procedures outlined in the USGS Hydroacoustics Webinar ***Review and Rating of ADCP Q Measurements*** (OSW 2012c). These procedures resulted in qualification of data as either Excellent, Good, Fair, or Poor, corresponding to levels of uncertainty ranging from 0-2%, 2-5%, 5-8%, and over 8%, respectively. In addition, the 2012 results were compared against published results from the United States, Canada, and New Zealand (Wagner and Mueller 2011). Results confirmed the accuracy of GPS-based discharge measurements for both stationary and moving bed conditions, provided that loop tests indicated upstream (i.e., valid) loop closures.

The compass errors that resulted in downstream loop closures are attributed to failure of the Sontek calibration algorithms to compensate for magnetic effects from the cataraft's outboard motor. For cases where the boat orientation remained relatively constant, the heading errors did not affect discharge accuracy. However, where significant changes in boat orientation were required, the heading errors resulted in failed loop tests and inaccurate GPS-based discharge results.

It is not clear that problems associated with the Sontek M9's compass will be resolved prior to the 2013 field season. To avoid continued problems, the Teledyne/RDI RiverRay ADCP is being considered for 2013 work. Although the RiverRay was initially produced with a Honeywell compass that had similar issues (OSW 2012d), it is now configured with the more reliable StreamPro compass. If pre-season testing indicates continued problems, the RiverRay software accepts heading information from external devices, including GPS-based systems that are not subject to magnetic effects.

After the initial cross section measurements during the high discharge campaign, some cross-sections were eliminated from additional discharge measurements as certain section did not have any tributary inflows between section, or other reasons to expect additional flow contributions. This was part of the original study design. The listing of all cross sections, with the measured flow values is shown in Table 4.2-2.

4.2.4. Other Transect Data

A thorough description of the vegetation conditions at each measured cross section and channel was developed and referenced to PRM and channel bank descriptions. This data was also provided in a format to be compatible with the GIS geospatial databases being developed for the Project. The series of photographs used for the vegetation descriptions at each section were developed into an image data set to be incorporated into the Project GIS spatial databases. The images and other field information were also used in the flow-routing modeling analysis to assist in the determination of surface roughness.

5. DISCUSSION AND CONCLUSION

The purpose of this study was to establish the initial survey control network and hydrologic network for the Project. It was also the first major hydrologic field campaign in the Susitna River watershed since the prior 1980s studies. The GPS control network was established for the study area, which will provide the survey foundation for all other studies. Three measurement campaigns where made during the 2012 open-water seasons. The intent was to measure high, moderate and low flow conditions. The June to July event did measure high flow conditions. During this measurement period, key lessons were learned about the complexity of the channels and flow conditions from the confluence of the Chulitna River downstream to PRM 80 (RM 76). Some of the conditions encountered included multiple channels (up to nine in some sections), shallow water with high velocities (up to 10 feet per second), trees and other woody debris hazards, quick-sand conditions on actively developing bars, channels with reverse flow conditions, and many dead-end channels. The successful and efficient measurement of cross-section profiles in this segment of the river will require lower water conditions than was encountered during the 2012 field campaign.

End of summer field measurements, intended on measuring low flow conditions, had two separate flooding events interrupt the trip. One flood resulted in the safe evacuation of the river crew from the Indian River camp they were using. Efforts were continued during this trip until river ice conditions resulted in ADCP measurements that would not meet the study QC standards and the discharge measurement portion of the field season was ended.

The gaging station network was then prepared for winter operations and any remaining field repairs were performed. The high water-level conditions going into winter resulted in a number of pressure transducers freezing into ice, others were taken out by the frequent fall ice jams and releases. Through the 2012 summer season, no personal injuries or environmental problems were encountered, in spite of the difficult working environment, flooding, and other logistical issues encountered during the summer.

Data sets from this study are available from the Alaska Energy Authority (AEA) upon request.

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7. TABLES

Table 3.2-1. Calculating 95% uncertainty for reciprocal transects.

No. of Reciprocal Transects	Approximate 95% Uncertainty (OSW 2012c)
8	COV * 0.8
6	COV * 1.0
4	COV * 1.2
2	Round COV to nearest whole percent, use 3% if COV rounds to zero or COV * 3.3 if COV rounds to 1 or greater

Table 3.2-2. ADCP check measurements.

Date	Time	ADCP Serial No.	Measured Q, cfs	Online Q, cfs	Percent Difference	Measured Stage, ft	
						Gage Datum	NAVD 88[1]
6/11/12	08:25	3061	9,580	9,920	-3.43	8.36 @ 10:45 hrs	UA[2]
6/11/12	10:10	2837	9,418	9,700	-2.91		
6/29/12	14:48	2837	30,378	32,300	-5.95	UA	693.77
8/13/12	12:54	3061	16,350	17,800	-8.15	9.32	691.69

Notes:
1 Average of left- and right-bank RTK elevations, PRM 140.0 (RM 136.7)
2 UA = unavailable

Table 4.1-1. GPS Survey Control Network Benchmarks.

Point No.	Date	Latitude	Longitude	Horiz. Accuracy (feet)	Horiz. Precision (feet)	Elevation (feet)	Vertical Accuracy (feet)	Vertical Precision (feet)	Descriptor
96	8/27/2012	62.8294421545	-148.5509790448	<= 0.05	<= 0.05	2366.021	<= 0.05	<= 0.05	R&M_BM22C
98	6/11/2012	62.2985896036	-150.1056570195	<= 0.05	<= 0.05	568.902	<= 0.05	<= 0.05	TALKEETNA_RESET
99	--	62.3210816242	-150.1044921632	Datum	Datum	350.865	Datum	Datum	DOT_GPS_38
100	6/6/2012	62.0999313983	-150.0762751529	<= 0.05	<= 0.05	240.011	<= 0.05	<= 0.05	CP_100
101	6/6/2012	62.1462485821	-150.1326291530	<= 0.05	<= 0.05	257.110	<= 0.05	<= 0.05	CP_101
102	6/6/2012	62.1832961043	-150.1575965881	<= 0.05	<= 0.05	276.225	<= 0.05	<= 0.05	CP_102
103	6/6/2012	62.2502825626	-150.1625537512	<= 0.05	<= 0.05	307.203	<= 0.05	<= 0.05	CP_103
104	6/6/2012	62.3091785852	-150.1216540100	<= 0.05	<= 0.05	336.854	<= 0.05	<= 0.05	CP_104
105	6/7/2012	62.3792717442	-150.1591861857	<= 0.05	<= 0.05	377.616	<= 0.05	<= 0.05	CP_105
106	6/7/2012	62.4486429192	-150.1326242226	<= 0.05	<= 0.05	422.413	<= 0.05	<= 0.05	CP_106
107	6/7/2012	62.5166562050	-150.1186592177	<= 0.05	<= 0.05	467.597	<= 0.05	<= 0.05	CP_107
108	6/7/2012	62.5782042562	-150.0460110421	<= 0.05	<= 0.05	512.172	<= 0.05	<= 0.05	CP_108
109	6/7/2012	62.6534474576	-149.9548473422	<= 0.05	<= 0.05	559.857	<= 0.05	<= 0.05	CP_109
110	6/9/2012	62.7104972520	-149.8323600083	<= 0.05	<= 0.05	620.325	<= 0.05	<= 0.05	CP_110
111	6/9/2012	62.7349166049	-149.7428299523	<= 0.05	<= 0.05	660.502	<= 0.05	<= 0.05	CP_111
112	6/9/2012	62.7758843958	-149.6892659082	<= 0.05	<= 0.05	705.033	<= 0.05	<= 0.05	CP_112
113	6/8/2012	62.7885480038	-149.6362530060	<= 0.05	<= 0.05	724.012	<= 0.05	<= 0.05	CP_113
114	6/9/2012	62.8206344717	-149.5533979849	<= 0.05	<= 0.05	773.193	<= 0.05	<= 0.05	CP_114
115	6/9/2012	62.8264892482	-149.4673679524	<= 0.05	<= 0.05	812.821	<= 0.05	<= 0.05	CP_115
116	6/25/2012	62.8303134832	-149.3799887264	<= 0.05	<= 0.05	849.674	<= 0.05	<= 0.05	CP_116

Point No.	Date	Latitude	Longitude	Horiz. Accuracy (feet)	Horiz. Precision (feet)	Elevation (feet)	Vertical Accuracy (feet)	Vertical Precision (feet)	Descriptor
117	6/10/2012	62.8085078497	-149.0017155136	<= 0.05	<= 0.05	1251.791	<= 0.05	<= 0.05	CP_117
118	6/10/2012	62.7771157386	-148.9933570086	<= 0.05	<= 0.05	1278.141	<= 0.05	<= 0.05	CP_118
119	6/10/2012	62.7678113366	-148.8411199706	<= 0.05	<= 0.05	1325.934	<= 0.05	<= 0.05	CP_119
120	6/13/2012	62.7591793360	-148.7298230021	<= 0.05	<= 0.05	1366.445	<= 0.05	<= 0.05	CP_120
121	6/13/2012	62.8131286883	-148.6615890254	<= 0.05	<= 0.05	1421.692	<= 0.05	<= 0.05	CP_121
122	6/13/2012	62.8225627266	-148.5923384076	<= 0.05	<= 0.05	1453.002	<= 0.05	<= 0.05	CP_122
123	9/10/2012	61.4054088732	-150.4601911115	<= 0.05	<= 0.05	32.185	<= 0.05	<= 0.05	CP_123
124	8/29/2012	62.6979445976	-147.5472023541	<= 0.05	<= 0.05	1912.328	<= 0.05	<= 0.05	CP_124
125	8/29/2012	62.8510278638	-148.0270373569	<= 0.05	<= 0.05	4325.140	<= 0.05	<= 0.05	CP_125
126	9/9/2012	61.8638599068	-150.1770700421	<= 0.05	<= 0.05	134.069	<= 0.05	<= 0.05	CP_126
127	9/11/2012	61.7270189776	-150.2092785958	<= 0.05	<= 0.05	86.930	<= 0.05	<= 0.05	CP_127
128	9/11/2012	61.4895371372	-150.5620496789	<= 0.05	<= 0.05	47.207	<= 0.05	<= 0.05	CP_128
129	9/10/2012	61.5434605531	-150.5168361788	<= 0.05	<= 0.05	61.524	<= 0.05	<= 0.05	CP_129

Notes:

1 Horizontal data is WGS84/AKSP Zone 4 U.S. Survey Feet, Vertical data is NAVD88/Geoid09.

Table 4.2-1. AEA gaging stations with PRMs, locations and measured parameters.

Station Name	Station ID	Project River Mile	Brailey River Mile	Latitude[1]	Longitude[1]	Measurement Parameters[2]
Susitna River Near Cantwell	ESS80	PRM 225.0	—	N 62.697770°	W 147.547290°	AT, WT, PT, CAM
Susitna River Below Deadman Creek	ESS70	PRM 187.1	RM 184.1	N 62.822990°	W 148.538340°	AT, WT, PT, CAM
Susitna River Below Fog Creek	ESS65	PRM 176.5	RM 173.9	N 62.764608°	W 148.774144°	AT, WT, PT, CAM
Susitna River Above Devil Creek	ESS60	PRM 168.1	RM 164.5	N 62.791830°	W 148.993810°	AT, WT, PT, CAM
Susitna River Below Portage Creek	ESS55	PRM 152.2	RM 148.7	N 62.830534°	W 149.383802°	AT, WT, PT, CAM
Susitna River at Curry	ESS50	PRM 124.1	RM 120.7	N 62.617157°	W 150.015167°	AT, WT, PT, CAM
Susitna River Below Lane Creek	ESS45	PRM 116.6	RM 113.0	N 62.525580°	W 150.114870°	AT, WT, PT, CAM
Susitna River Above Whiskers Creek	ESS40	PRM 107.2	RM 103.0	N 62.399145°	W 150.137222°	AT, WT, PT, CAM
Susitna River at Chulitna River	ESS35	PRM 102.1	RM 98.0	N 62.337906°	W 150.142737°	AT, WT, PT, CAM
Susitna River Below Twister Creek	ESS30	PRM 98.4	RM 95.0	N 62.294553°	W 150.115996°	AT, WT, PT, CAM
Susitna River at Susitna Station	ESS20	PRM 29.9	—	N 61.544250°	W 150.515332°	AT, WT, PT, CAM
Susitna River Near Dinglishna Hill	ESS15	PRM 24.7	—	N 61.489539°	W 150.562073°	AT, WT, PT, CAM
Susitna River Below Flat Horn Lake	ESS10	PRM 17.4	—	N 61.405410°	W 150.460214°	AT, WT, PT, CAM

Notes:
1 Horizontal data is WGS84/AKSP Zone 4 U.S. Survey Feet
2 AT, air temperature; WT, water temperature; PT, pressure transducer; CAM, camera.

Table 4.2-2. Table of cross-section discharge measurement dates and preliminary discharge values.

Project River Mile	Brailey River Mile	High Q Trip			Mid Q Trip			Low Q Trip		
		Date	Time	Discharge	Date	Time	Discharge	Date	Time	Discharge
PRM 225.0	RM 223.0	6/14/12	17:57	26,932	8/9/12	15:03	11,260	--	--	--
PRM 187.2	RM 184.1	6/17/12	16:30	27,698	8/6/12	16:13	14,707	9/15/12	13:17	7,838
PRM 186.2	RM 183.4	6/18/12	14:13	24,493	8/6/12	17:05	14,419	9/15/12	14:05	7,630
PRM 185.5	RM 182.8	6/18/12	16:10	25,389	--	--	--	--	--	--
PRM 185.2	RM 182.6	6/19/12	13:00	26,676	--	--	--	--	--	--
PRM 184.9	RM 182.2	6/19/12	15:49	27,619	8/6/12	18:24	14,239	9/15/12	14:57	7,714
PRM 184.4	RM 181.7	6/19/12	16:51	27,886	8/7/12	12:38	14,775	9/15/12	15:52	8,353
PRM 183.3	RM 180.3	6/20/12	13:19	29,426	8/7/12	13:35	14,183	9/15/12	16:41	8,310
PRM 182.9	RM 179.8	6/20/12	16:01	29,218	--	--	--	--	--	--
PRM 181.6	RM 178.9	6/20/12	17:56	29,645	8/7/12	14:44	14,705	9/15/12	17:55	8,689
PRM 179.5	RM 176.8	6/21/12	12:28	30,866	8/7/12	15:41	14,345	9/14/12	17:05	8,361
PRM 178.5	RM 176.1	6/16/12	18:35	29,756	8/7/12	16:37	14,799	9/14/12	17:47	8,738
PRM 176.5	RM 173.9	6/21/12	14:40	31,240	8/8/12	12:07	14,559	9/16/12	14:50	10,768
PRM 174.9	RM 172.0	6/21/12	16:12	31,163	--	--	--	--	--	--
PRM 173.1	RM 170.0	6/21/12	17:39	30,571	--	--	--	9/16/12	16:29	11,082
PRM 170.1	RM 167.0	6/22/12	12:56	31,121	8/8/12	15:16	14,568	9/16/12	17:33	11,137
PRM 168.1	RM 164.5	6/22/12	14:33	32,265	8/8/12	16:03	14,655	9/17/12	15:19	14,619
PRM 153.7	RM 150.2	6/25/12	17:15	32,162	8/10/12	15:03	14,588	--	--	--
PRM 152.9	RM 149.5	6/26/12	13:43	30,487	--	--	--	--	--	--
PRM 152.1	RM 148.7	6/26/12	15:38	30,036	8/10/12	16:07	15,351	9/29/12	15:20	18,488
PRM 151.1	RM 147.6	6/25/12	14:00	33,180	--	--	--	--	--	--
PRM 148.3	RM 144.8	6/26/12	18:24	32,114	8/10/12	18:03	14,941	--	--	--
PRM 146.6	RM 143.2	6/27/12	12:24	31,030	--	--	--	--	--	--
PRM 145.7	RM 142.3	6/27/12	13:51	31,396	8/12/12	13:12	17,354	9/29/12	16:51	18,131
PRM 145.5	RM 142.1	6/27/12	14:40	31,868	--	--	--	--	--	--
PRM 144.9	RM 141.5	6/27/12	17:01	31,949	--	--	--	--	--	--
PRM 144.3	RM 140.8	6/27/12	18:50	31,121	--	--	--	--	--	--
PRM 143.5	RM 140.2	6/28/12	12:17	30,330	8/12/12	14:58	17,006	--	--	--
PRM 143.0	RM 139.4	6/28/12	13:53	29,492	--	--	--	--	--	--
PRM 142.2	RM 138.9	6/28/12	15:15	29,753	8/12/12	16:29	16,798	9/29/12	17:45	18,301
PRM 141.9	RM 138.5	6/28/12	16:27	30,583	8/12/12	17:13	16,803	--	--	--
PRM 141.7	RM 138.2	6/28/12	17:41	30,555	--	--	--	--	--	--
PRM 140.0	RM 136.7	6/29/12	14:48	30,378	8/13/12	12:54	16,350	9/30/12	13:56	17,619
PRM 139.8	RM 136.4	6/29/12	16:21	30,378	--	--	--	--	--	--
PRM 139.0	RM 135.7	6/30/12	13:56	28,039	8/13/12	13:58	16,449	--	--	--

PRM 138.7	RM 135.4	6/30/12	14:51	28,230	8/13/12	14:48	16,344	--	--	--
PRM 138.1	RM 134.7	6/30/12	16:33	28,203	--	--	--	--	--	--
PRM 137.6	RM 134.3	6/30/12	18:13	27,893	8/13/12	16:14	16,409	9/30/12	15:00	17,382
PRM 136.7	RM 133.3	7/1/12	13:35	26,756	--	--	--	--	--	--
PRM 136.2	RM 132.9	7/1/12	16:06	26,943	--	--	--	--	--	--
PRM 135.0	RM 131.8	7/1/12	18:33	26,526	8/13/12	17:41	15,627	--	--	--
PRM 134.3	RM 131.2	7/2/12	12:16	25,463	--	--	--	10/1/12	13:40	15,568
PRM 134.1	RM 130.9	7/2/12	13:18	26,166	8/14/12	13:14	16,491	--	--	--
PRM 133.8	RM 130.5	7/2/12	14:30	25,715	8/14/12	14:05	16,275	--	--	--
PRM 133.3	RM 130.0	7/2/12	16:22	25,678	--	--	--	--	--	--
PRM 132.6	RM 129.4	7/2/12	17:57	25,046	8/14/12	15:17	16,039	--	--	--
PRM 131.4	RM 128.1	7/3/12	22:08	28,628	--	--	--	--	--	--
PRM 129.7	RM 126.6	7/3/12	17:33	28,243	8/14/12	17:00	16,330	10/1/12	16:16	15,731
PRM 128.1	RM 124.4	7/4/12	15:40	26,748	8/15/12	12:50	15,926	--	--	--
PRM 126.8	RM 123.3	7/4/12	17:22	27,608	8/15/12	13:40	16,078	10/1/12	17:02	15,582
PRM 126.1	RM 122.6	7/5/12	14:24	27,248	--	--	--	--	--	--
PRM 125.4	RM 121.8	7/5/12	16:38	26,427	--	--	--	--	--	--
PRM 124.1	RM 120.7	7/5/12	18:11	26,132	8/15/12	14:27	16,161	10/1/12	17:42	15,582
PRM 123.7	RM 120.3	7/6/12	12:18	23,875	--	--	--	--	--	--
PRM 122.7	RM 119.3	7/6/12	14:23	23,331	--	--	--	--	--	--
PRM 122.6	RM 119.2	7/6/12	15:59	22,890	8/15/12	16:13	16,287	--	--	--
PRM 120.7	RM 117.2	7/6/12	17:19	22,687	--	--	--	--	--	--
PRM 119.9	RM 116.4	7/7/12	12:19	20,715	8/16/12	12:54	16,005	10/3/12	14:47	13,998
PRM 118.4	RM 115.0	7/7/12	14:06	20,656	--	--	--	--	--	--
PRM 117.4	RM 114.0	7/7/12	16:15	20,747	--	--	--	--	--	--
PRM 116.6	RM 113.0	7/7/12	17:36	20,665	8/16/12	14:15	16,136	10/3/12	15:53	14,323
PRM 116.3	RM 112.7	7/8/12	12:42	23,766	--	--	--	--	--	--
PRM 115.7	RM 112.2	7/8/12	14:05	25,006	--	--	--	--	--	--
PRM 115.4	RM 111.8	7/8/12	16:13	25,958	--	--	--	--	--	--
PRM 114.4	RM 110.9	7/8/12	18:29	25,860	--	--	--	--	--	--
PRM 113.6	RM 110.0	7/9/12	14:23	28,329	8/16/12	16:38	16,311	10/3/12	16:41	13,476
PRM 111.9	RM 108.4	7/9/12	15:23	28,296	--	--	--	--	--	--
PRM 110.5	RM 106.7	7/9/12	16:46	28,825	8/17/12	14:57	15,254	10/3/12	17:33	14,172
PRM 108.3	RM 104.8	--	--	--	8/17/12	17:55	16,394			
PRM 107.1	RM 103.0	7/9/12	18:26	28,409	8/18/12	13:12	15,508	10/4/12	14:10	14,558
PRM 106.1	RM 102.4	--	--	--	8/18/12	14:22	15,278	--	--	--
PRM 105.3	RM 101.5	--	--	--	8/18/12	15:52	15,362	--	--	--
PRM 104.7	RM 101.0	--	--	--	8/18/12	17:48	15,377	--	--	--
PRM 104.1	RM 100.4	--	--	--	8/19/12	12:49	15,345	--	--	--

PRM 103.5	RM 99.6	--	--	--	--	--	--	10/4/12	16:49	14,575
PRM 102.7	RM 98.8	7/10/12	13:53	26,635	--	--	--	--	--	--
PRM 101.4	RM 98.0	--	--	--	--	--	--	--	--	--
PRM 98.4	RM 95.0	7/11/12	14:09	46,499	8/20/12	14:51	40,623	10/5/12	14:37	39,065
PRM 97.0	RM 94.0	7/11/12	18:27	45,118	8/20/12	17:03	40,261	--	--	--
PRM 91.6	RM 87.7				8/21/12	14:55	46,330	--	--	--
PRM 91.0	RM 86.9	7/12/12	15:39	43,922	8/21/12	16:51	46,197	--	--	--
PRM 88.4	RM 84.6	--	--	--	8/22/12	15:01	41,697	--	--	--
PRM 87.1	RM 83.0	7/12/12	18:00	42,550	--	--	--	--	--	--
PRM 86.3	RM 82.0	7/13/12	13:13	41,895	--	--	--	--	--	--
PRM 85.4	RM 81.2	--	--	--	8/22/12	18:01	40,468	--	--	--
PRM 84.4	RM 80.0	--	--	--	8/23/12	15:16	36,988	--	--	--
PRM 83.0	RM 79.0	7/13/12	16:09	41,975	--	--	--	--	--	--
PRM 82.3	RM 78.0	--	--	--	8/23/12	17:52	37,947	--	--	--
PRM 80.0	RM 76.0	--	--	--	8/24/12	15:07	36,580	--	--	--

8. FIGURES

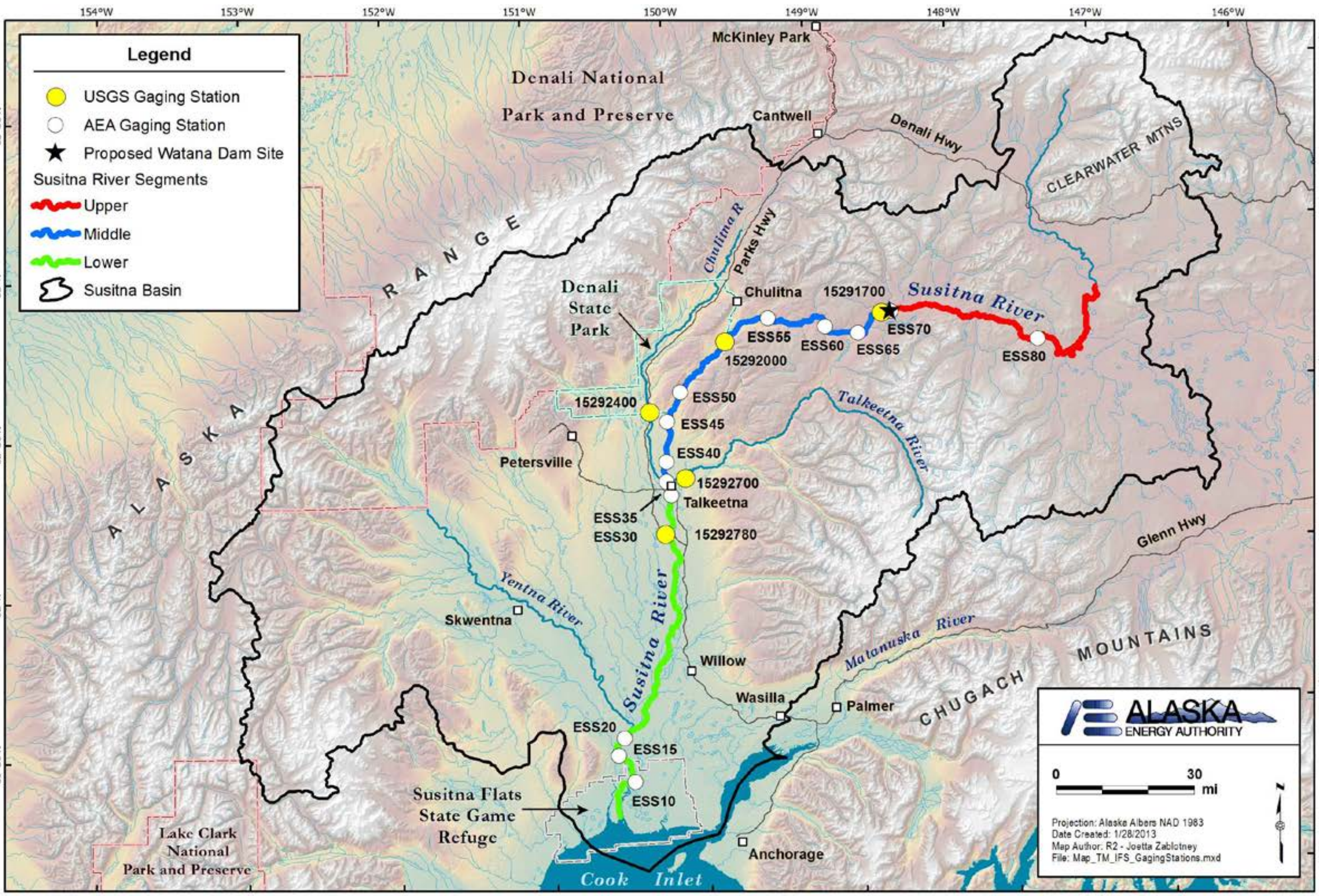


Figure 1-1. Map of general study area for the study showing station locations.

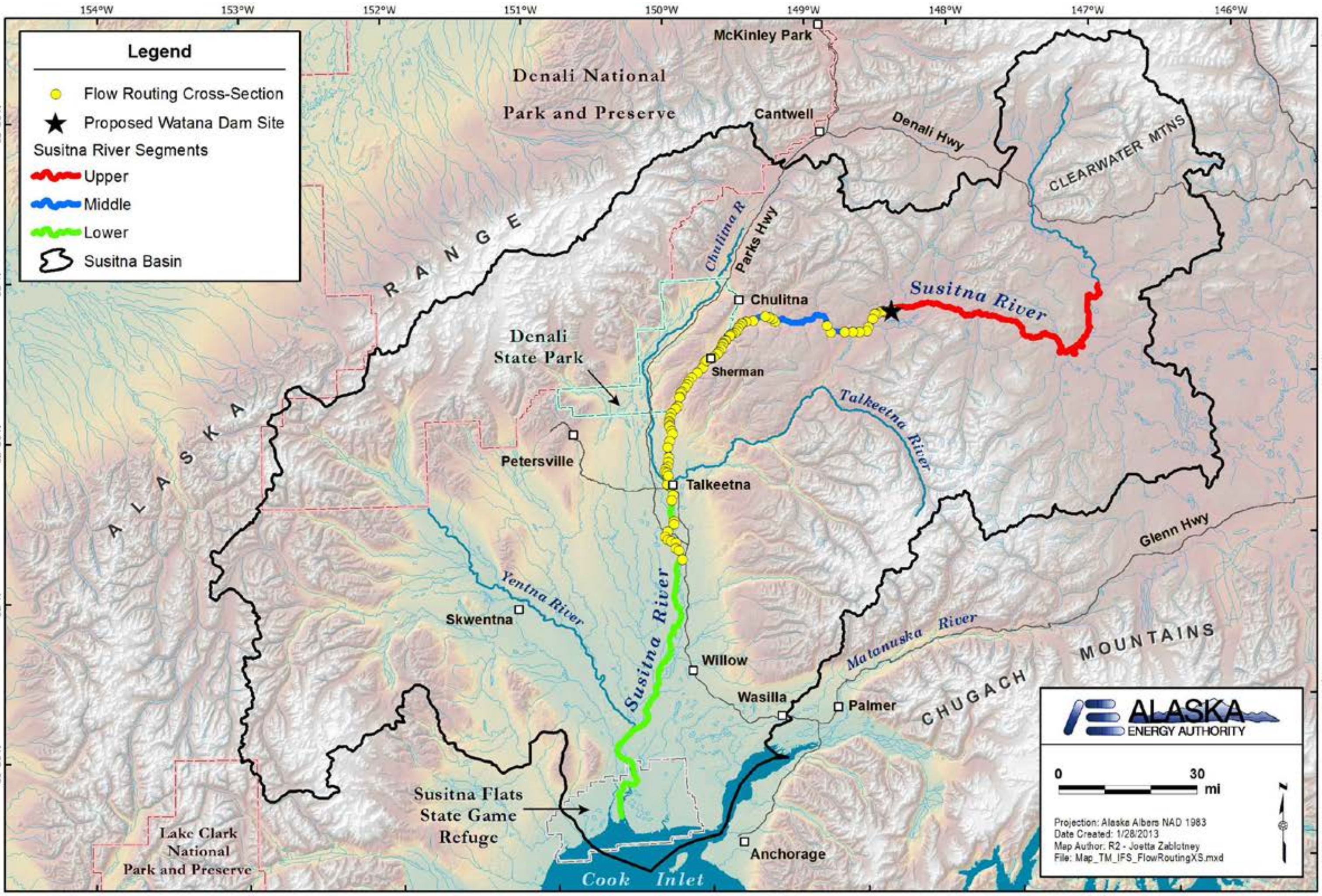
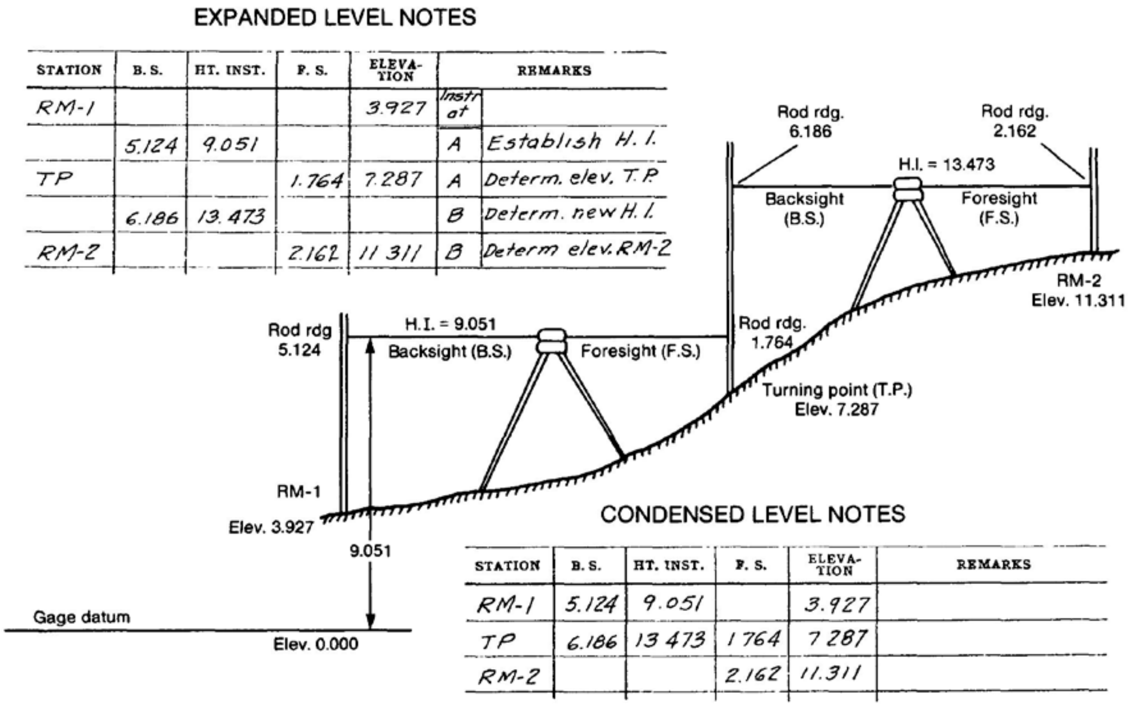


Figure 2-1. Map of general study area for the study showing cross-section locations.



EXPANDED LEVEL NOTES

STATION	B. S.	HT. INST.	F. S.	ELEVATION	Instr at	REMARKS
RM-1				3.927		
	5.124	9.051			A	Establish H. I.
TP			1.764	7.287	A	Determ. elev. T.P.
	6.186	13.473			B	Determ. new H. I.
RM-2			2.162	11.311	B	Determ elev. RM-2

CONDENSED LEVEL NOTES

STATION	B. S.	HT. INST.	F. S.	ELEVATION	REMARKS
RM-1	5.124	9.051		3.927	
TP	6.186	13 473	1 764	7 287	
RM-2			2.162	11.311	

Figure 3.1-1. Level-loop survey methods (Kennedy 1990).

Figure 3.2-1. ADCP cataraft in 1-foot standing waves at PRM 183.5, August 7, 2012.

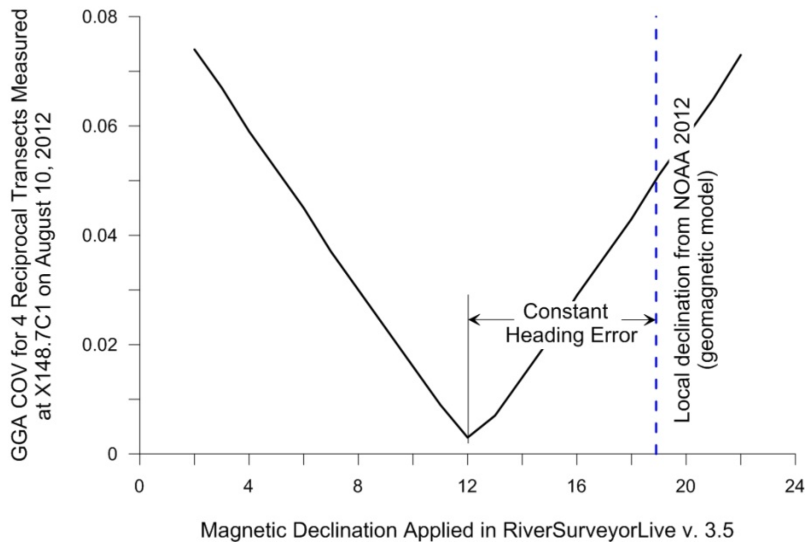


Figure 3.2-2. Constant heading error based on GGA COV.

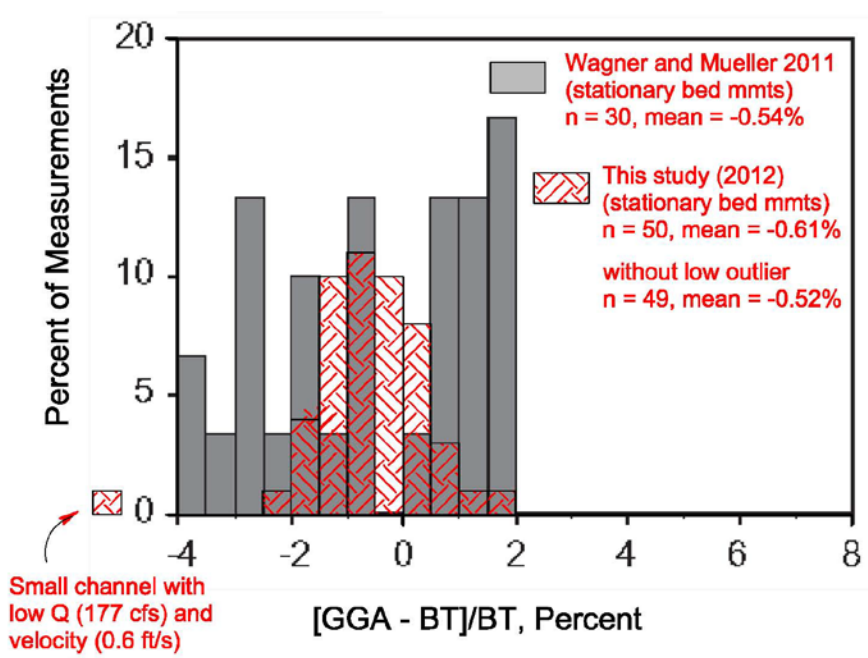


Figure 3.2-3. Accuracy of stationary bed GGA measurements.

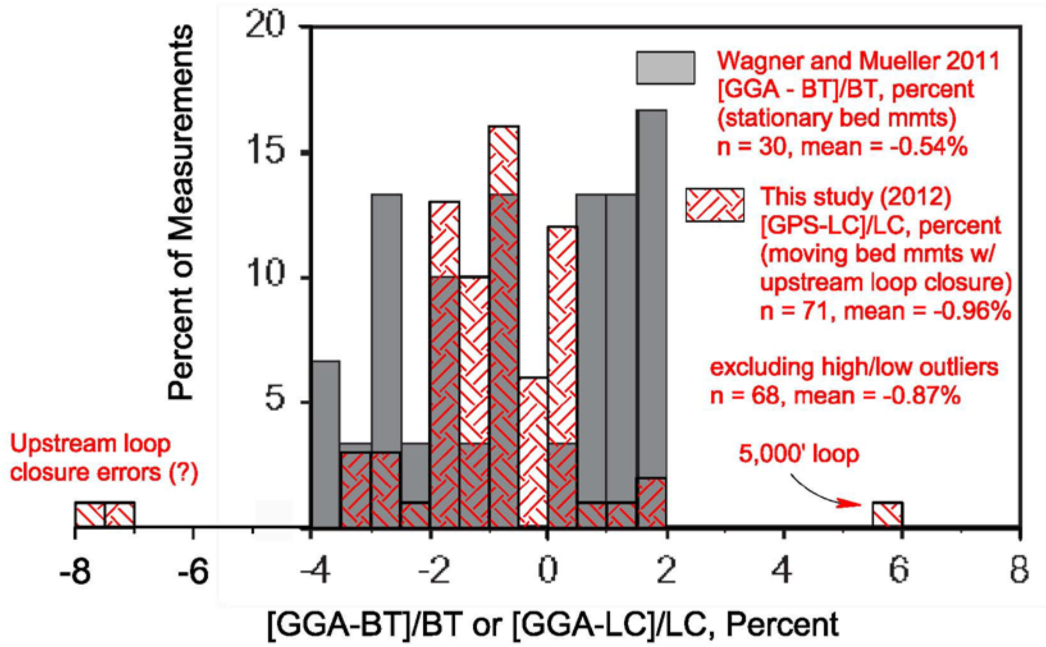


Figure 3.2-4. Accuracy of moving bed GGA measurements.

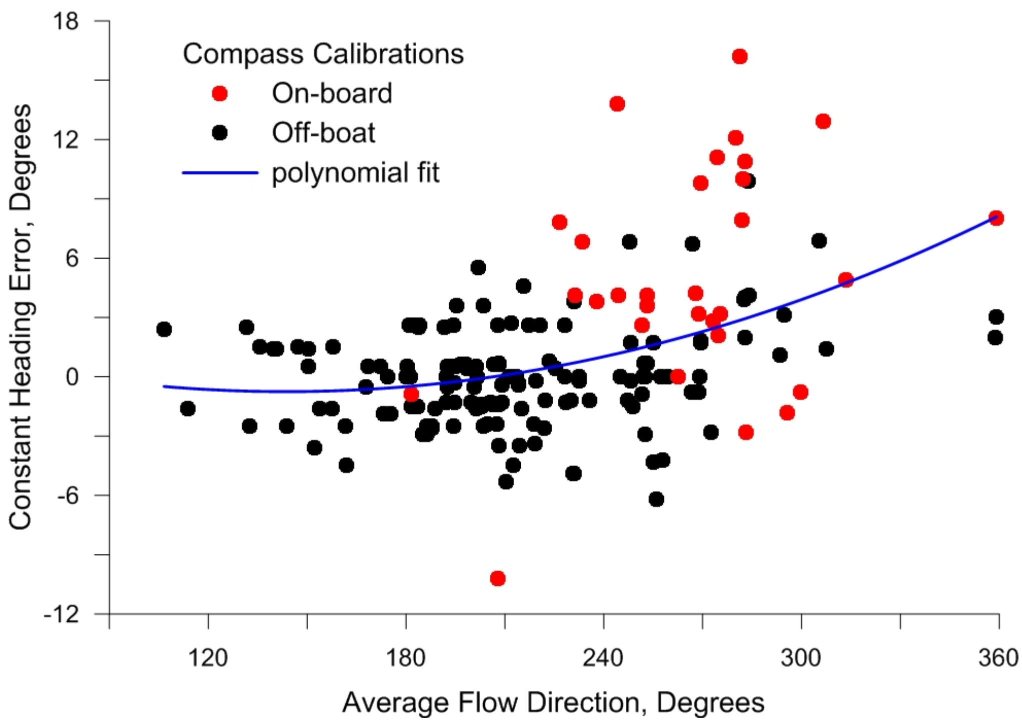


Figure 3.2-5. Flow direction versus constant heading error.

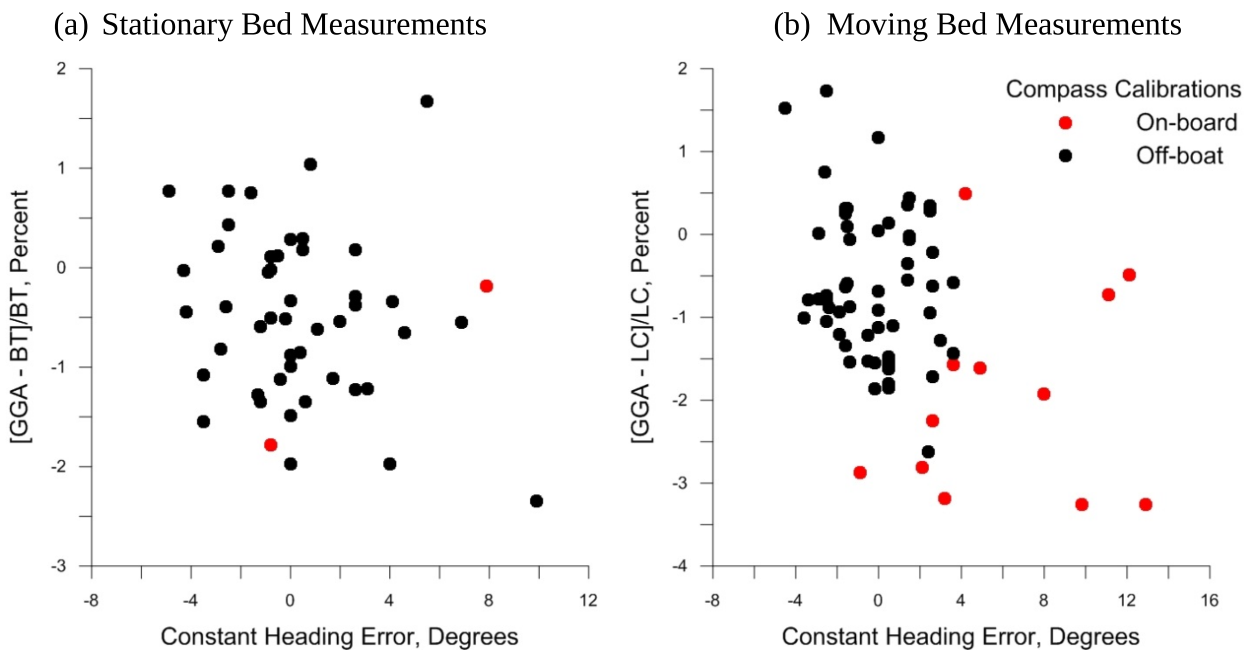


Figure 3.2-6. GGA accuracy versus constant heading error, excluding high and low outliers.

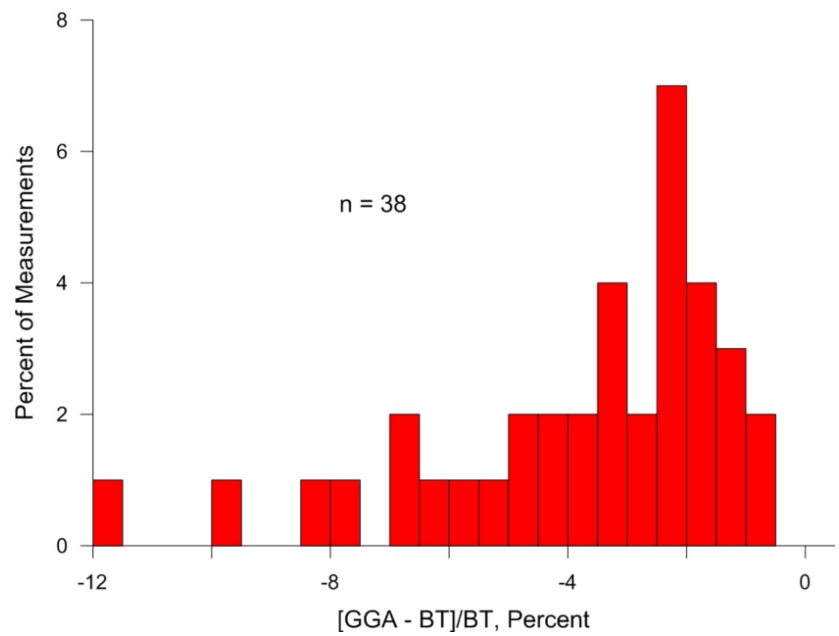


Figure 3.2-7. GGA accuracy at sites with downstream (invalid) loop closures.

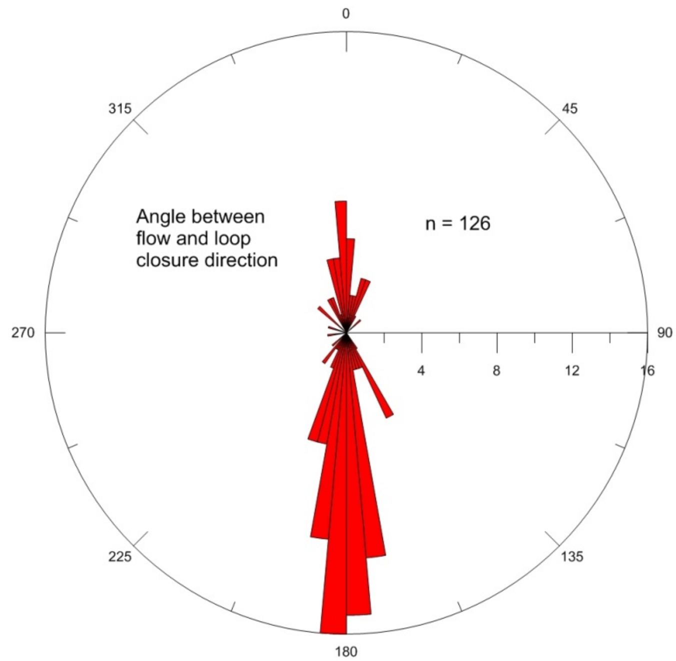


Figure 3.2-8. Proportion of upstream versus downstream loop closures.

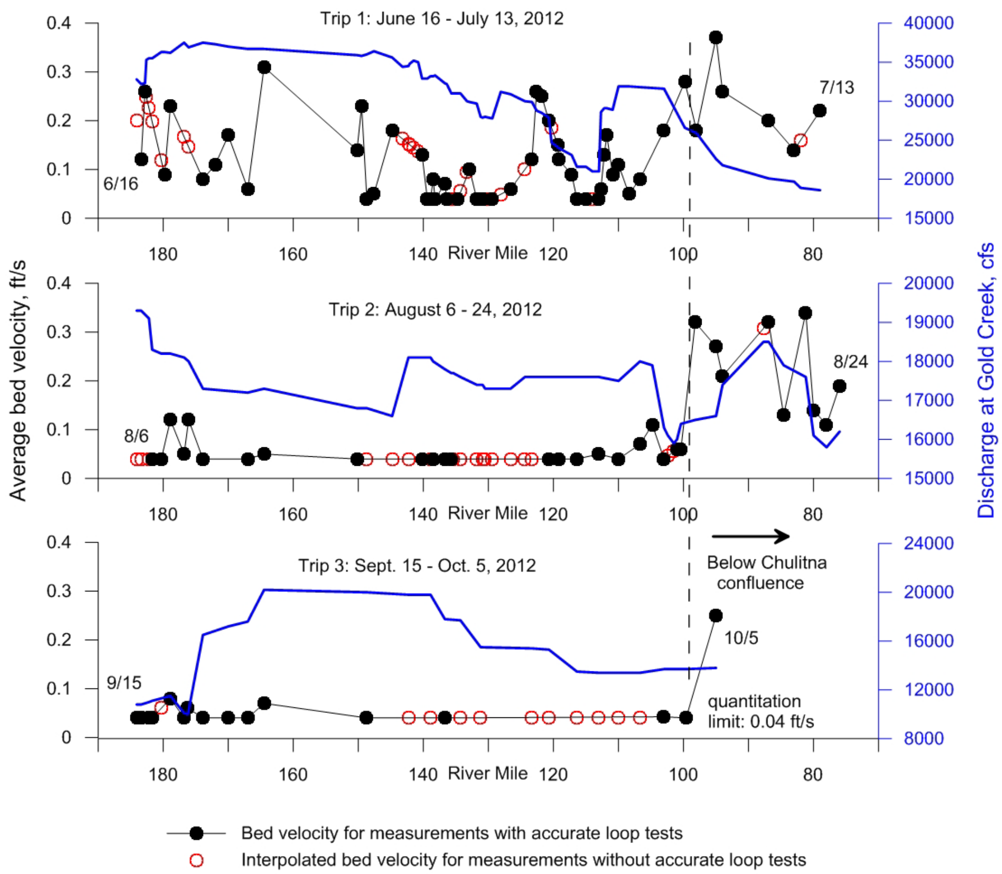


Figure 3.2-9. Moving bed velocity versus Brailey river mile. See Attachment 3 for conversions between Brailey river miles and PRMs.

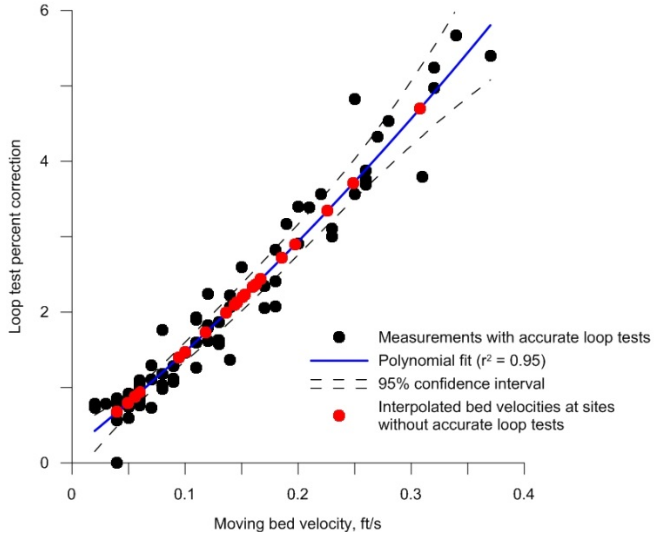


Figure 3.2-10. Moving bed velocity vs. loop test percent correction.

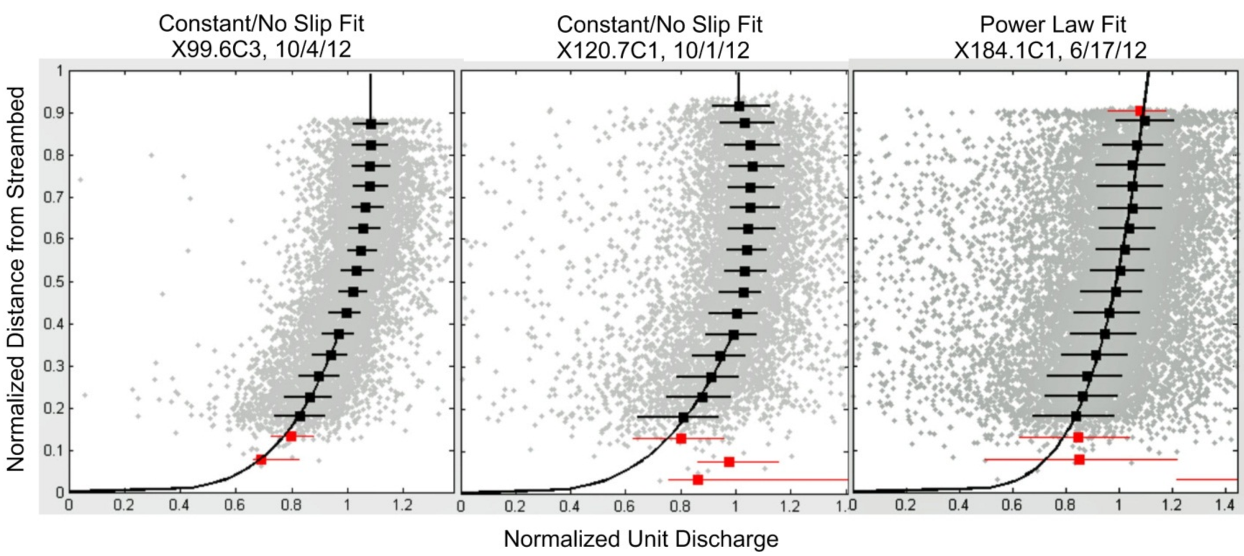


Figure 3.2-11. Example velocity profiles.

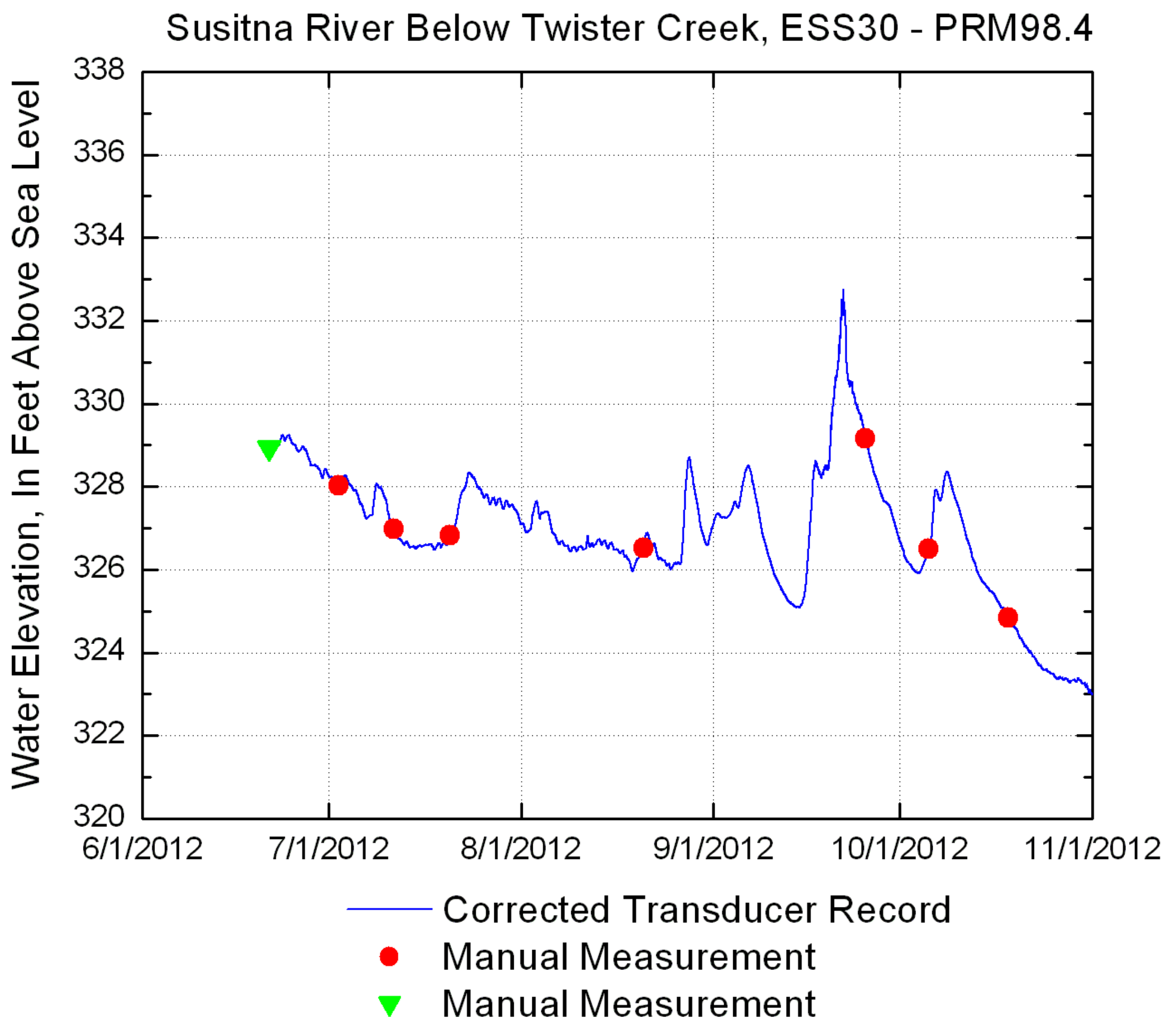


Figure 3.2-12. Example gaging station water level plot showing manual water level measurements and the continuous data measured by pressure transducers.

Figure 3.2-13. Example of image used for vegetation description at PRM 174.9 (RM 172.0); the image depicts white spruce forest on the right bank of the channel.

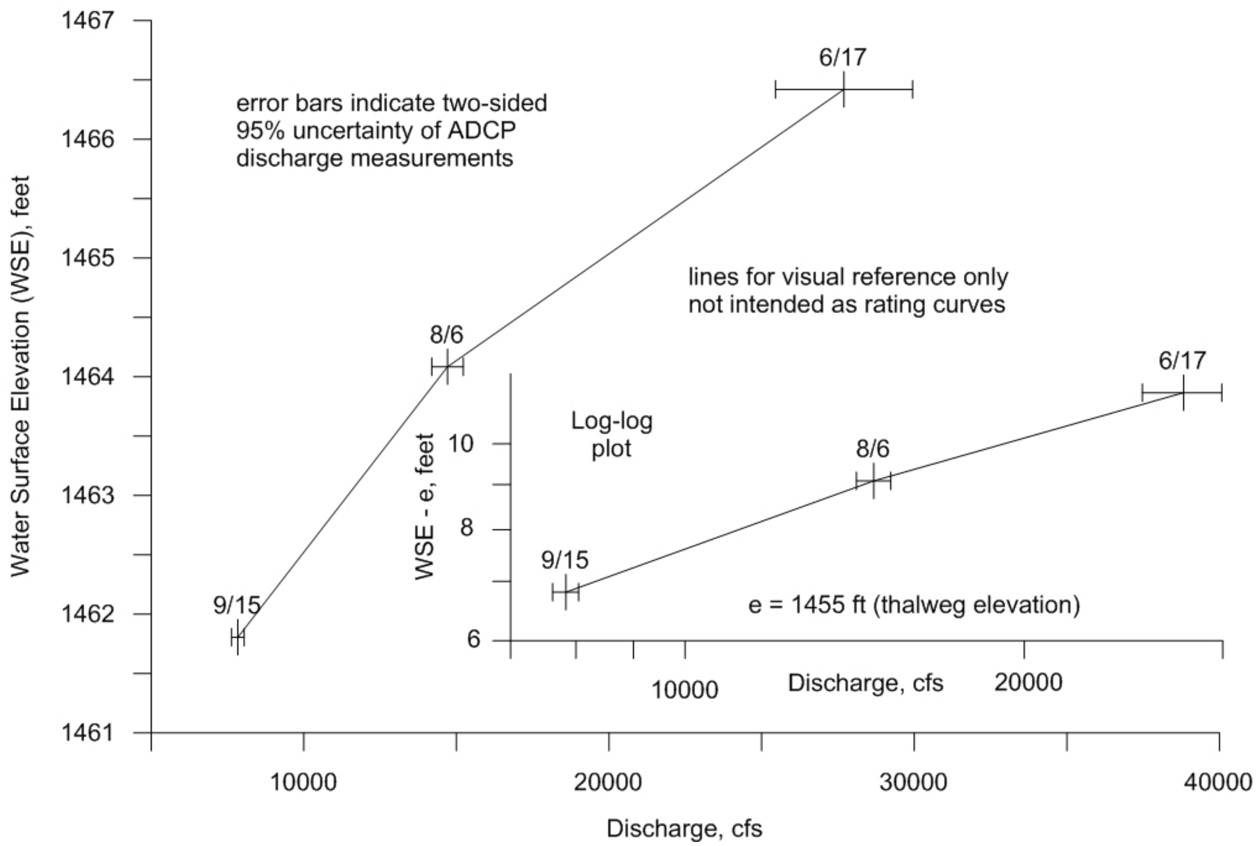


Figure 3.3-1. Example rating curve points and thalweg elevation.

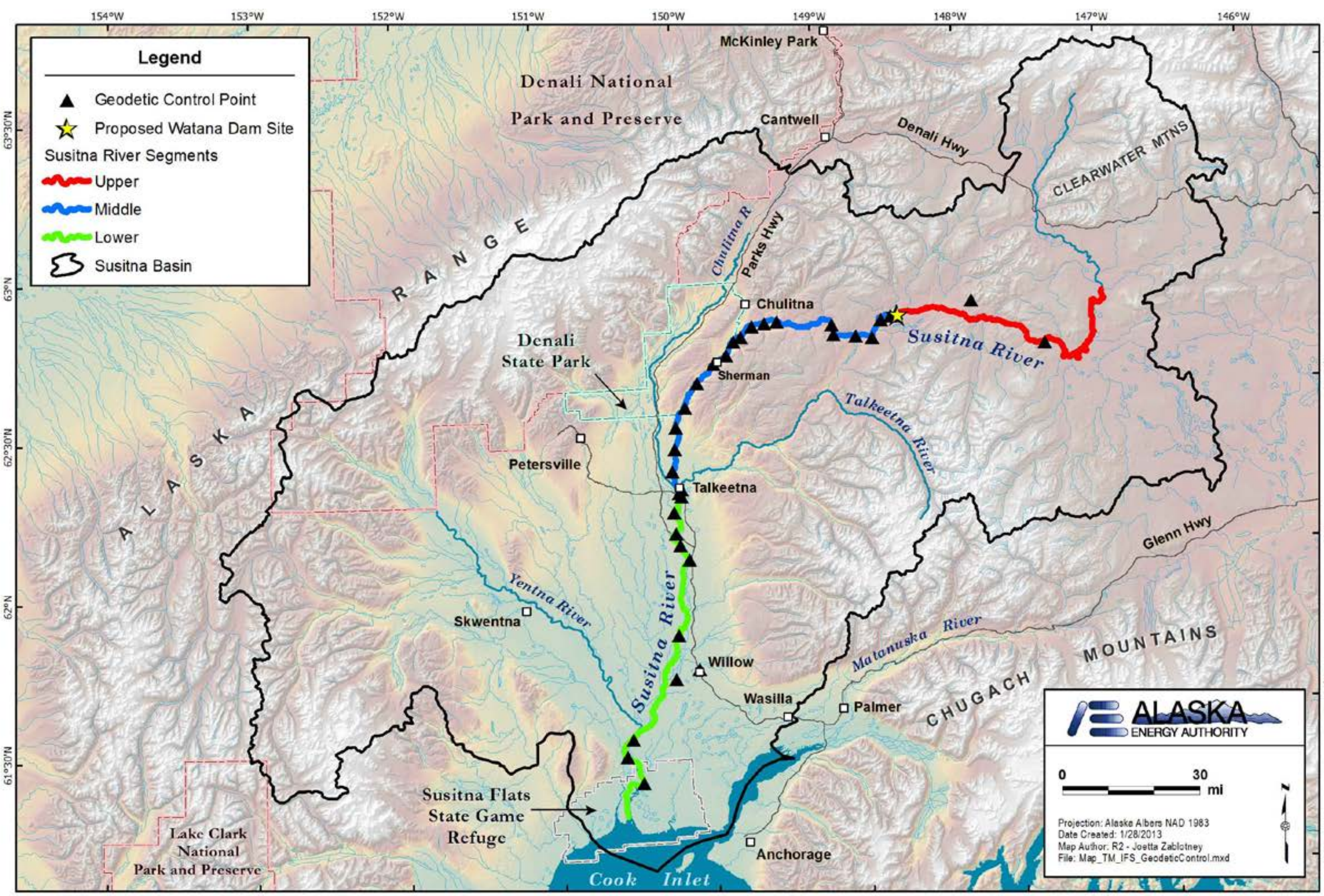


Figure 4.1-1. Survey control network.

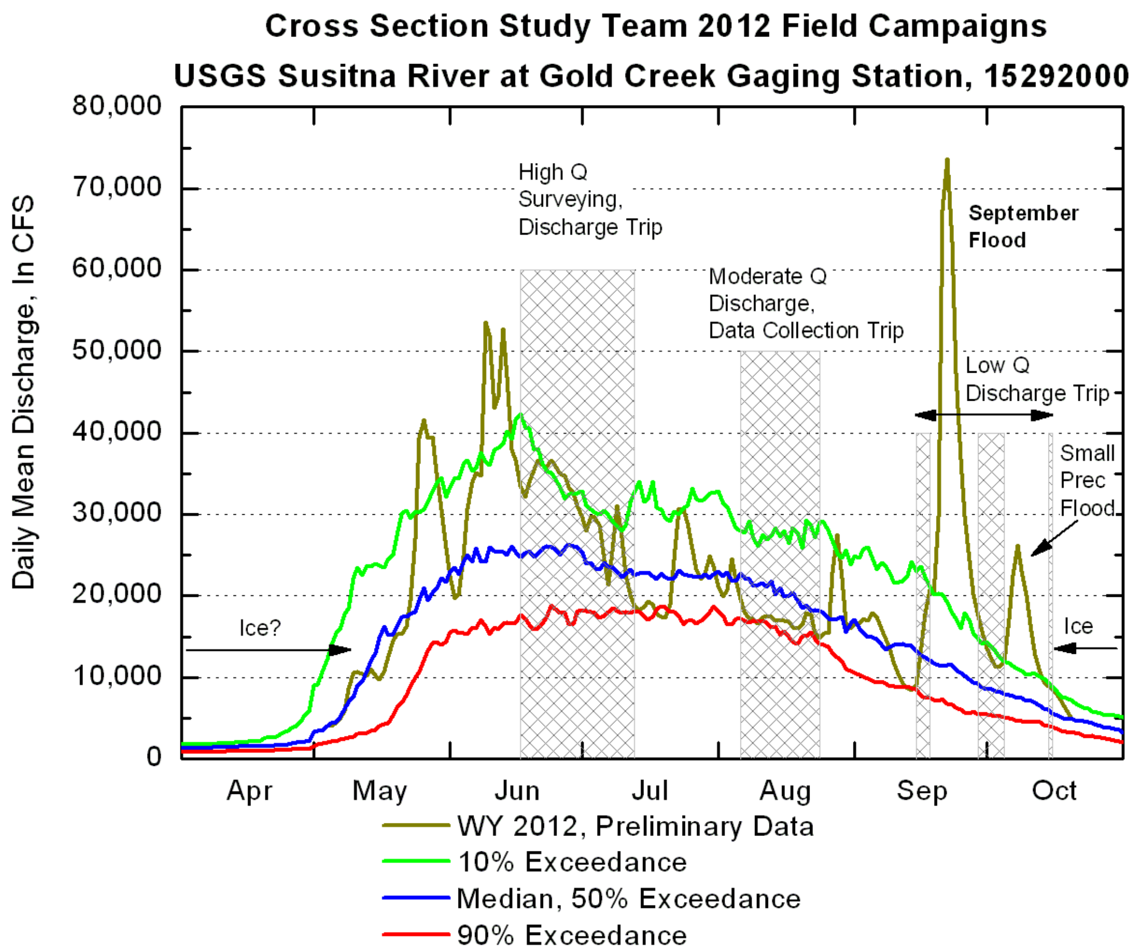


Figure 4.2-1. 2012 transect and flow measurement campaign and flow conditions.

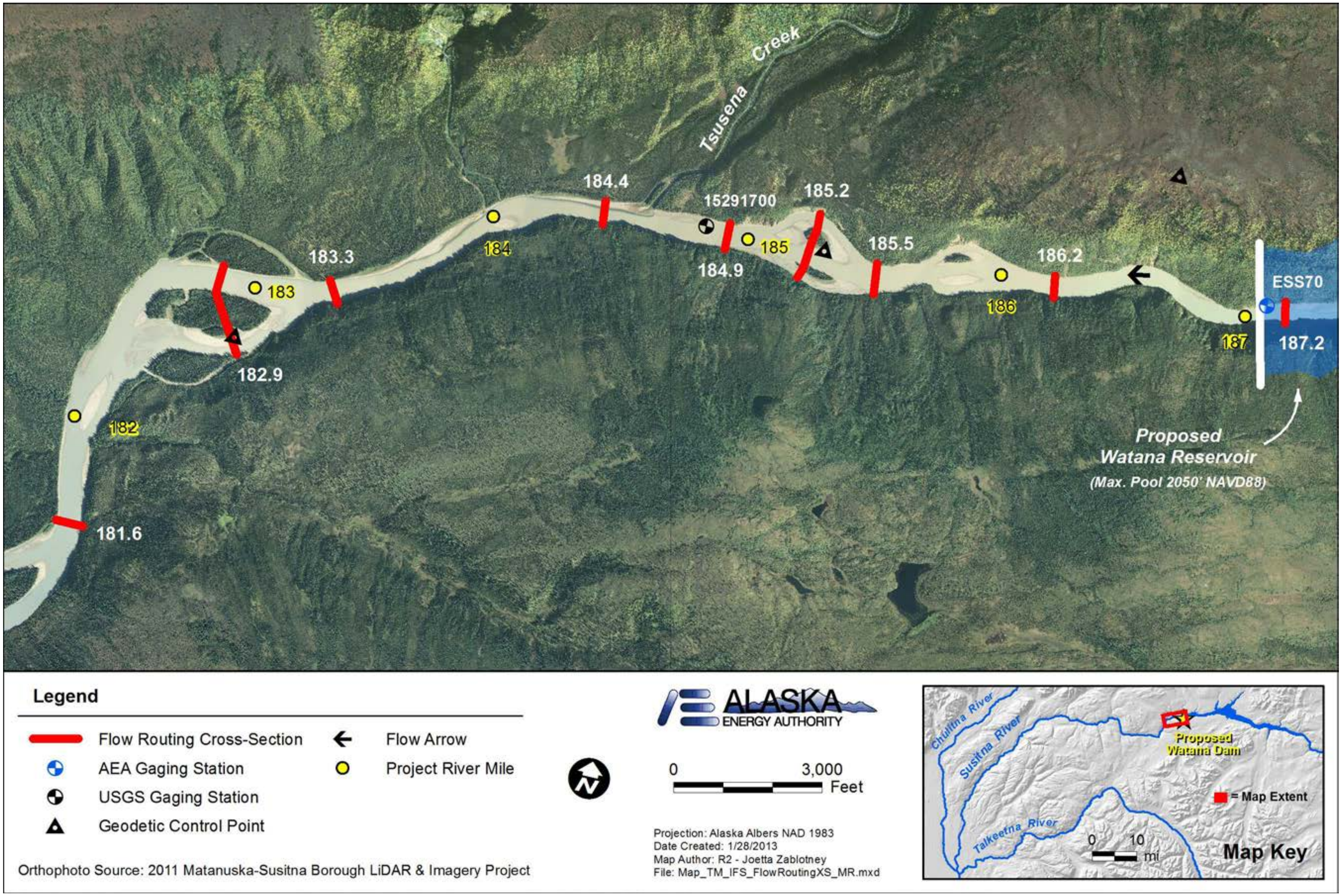


Figure 4.2-2. Maps of cross-section locations, survey control network benchmarks and gaging stations. The map covers the approximate river reach from PRM 187 down stream to PRM 181.

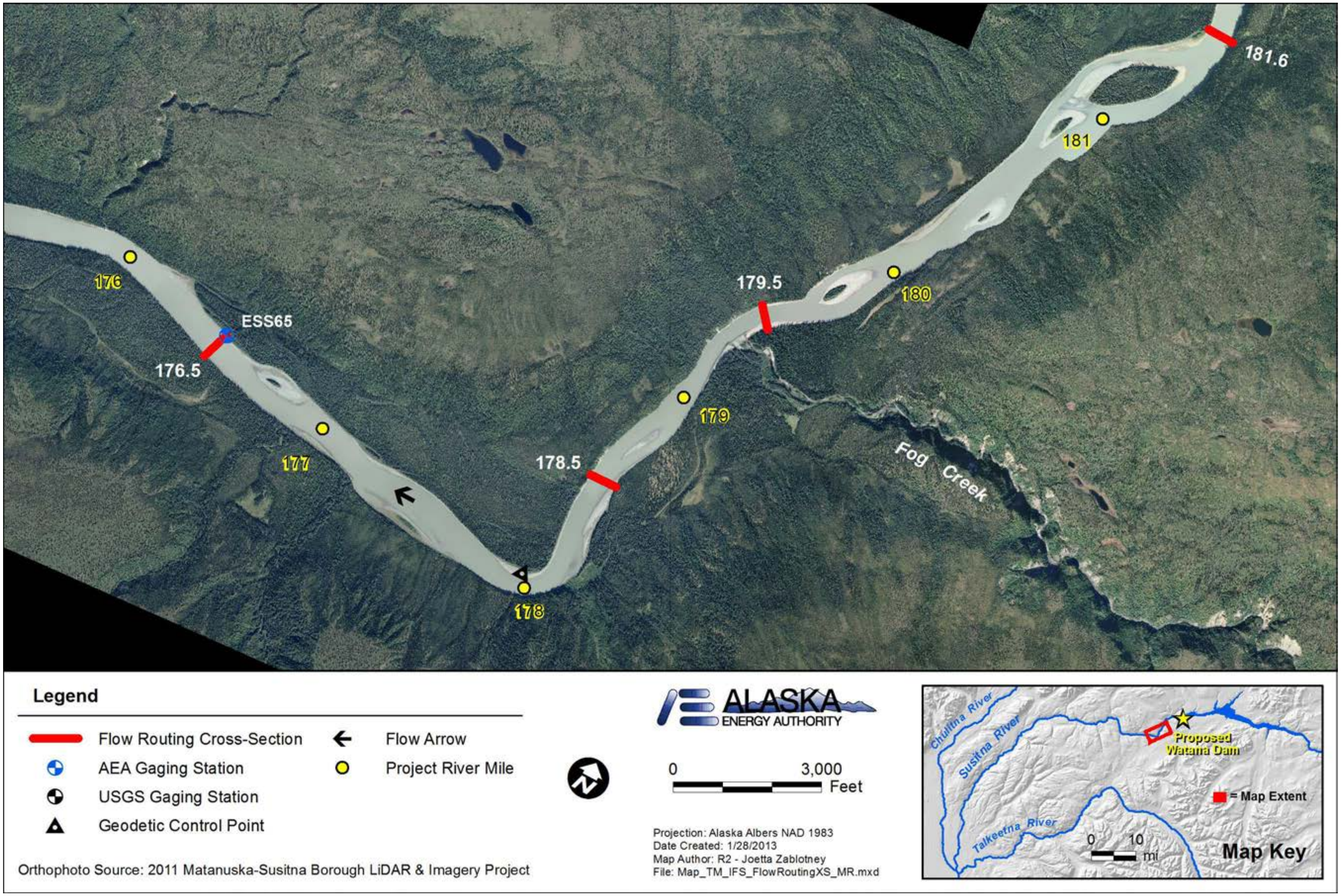


Figure 4.2-3. Maps of cross-section locations, survey control network benchmarks and gaging stations. The map covers the approximate river reach from PRM 181 down stream to PRM 176.

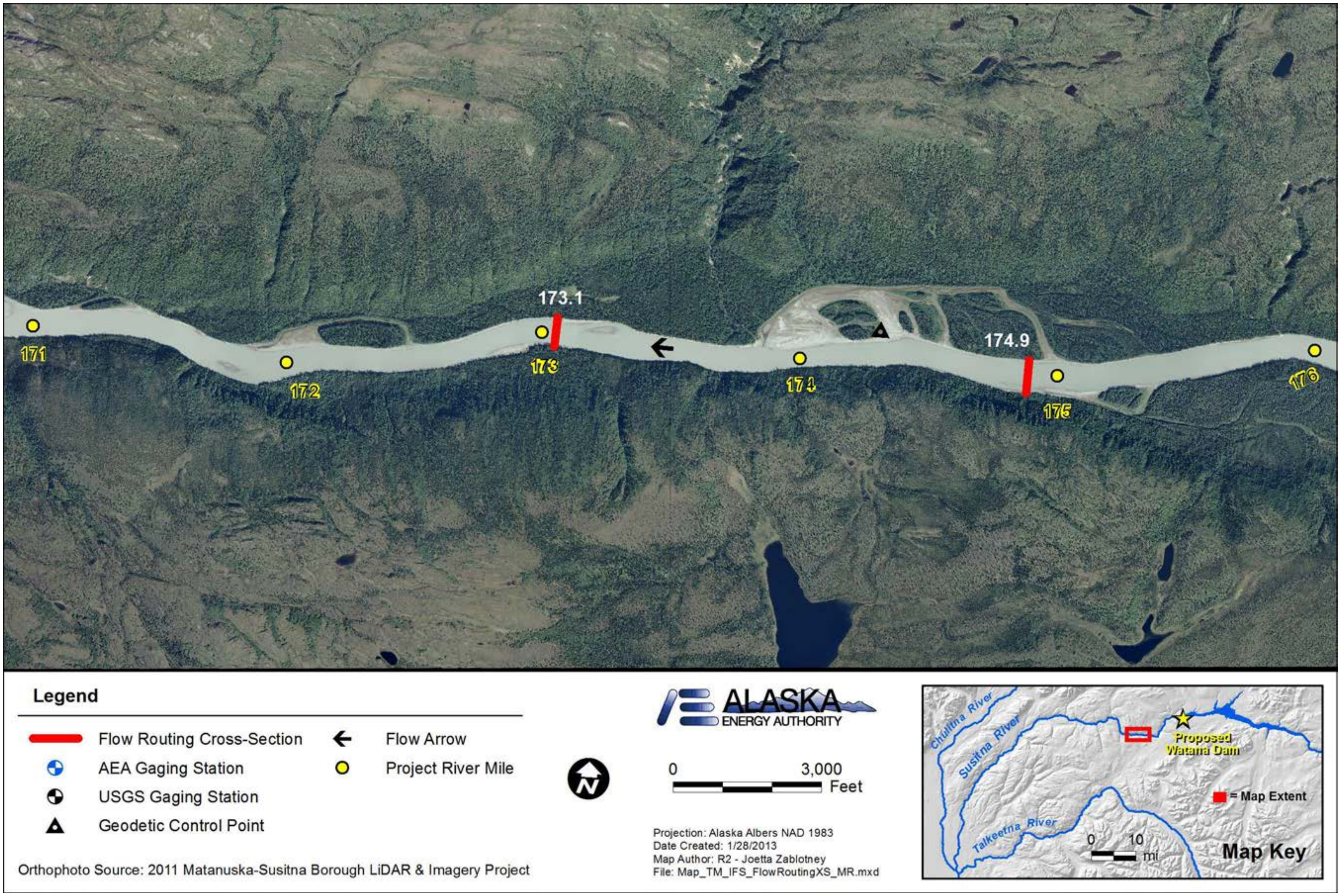


Figure 4.2-4. . Maps of cross-section locations, survey control network benchmarks and gaging stations. The map covers the approximate river reach from PRM 176 down stream to PRM 171.

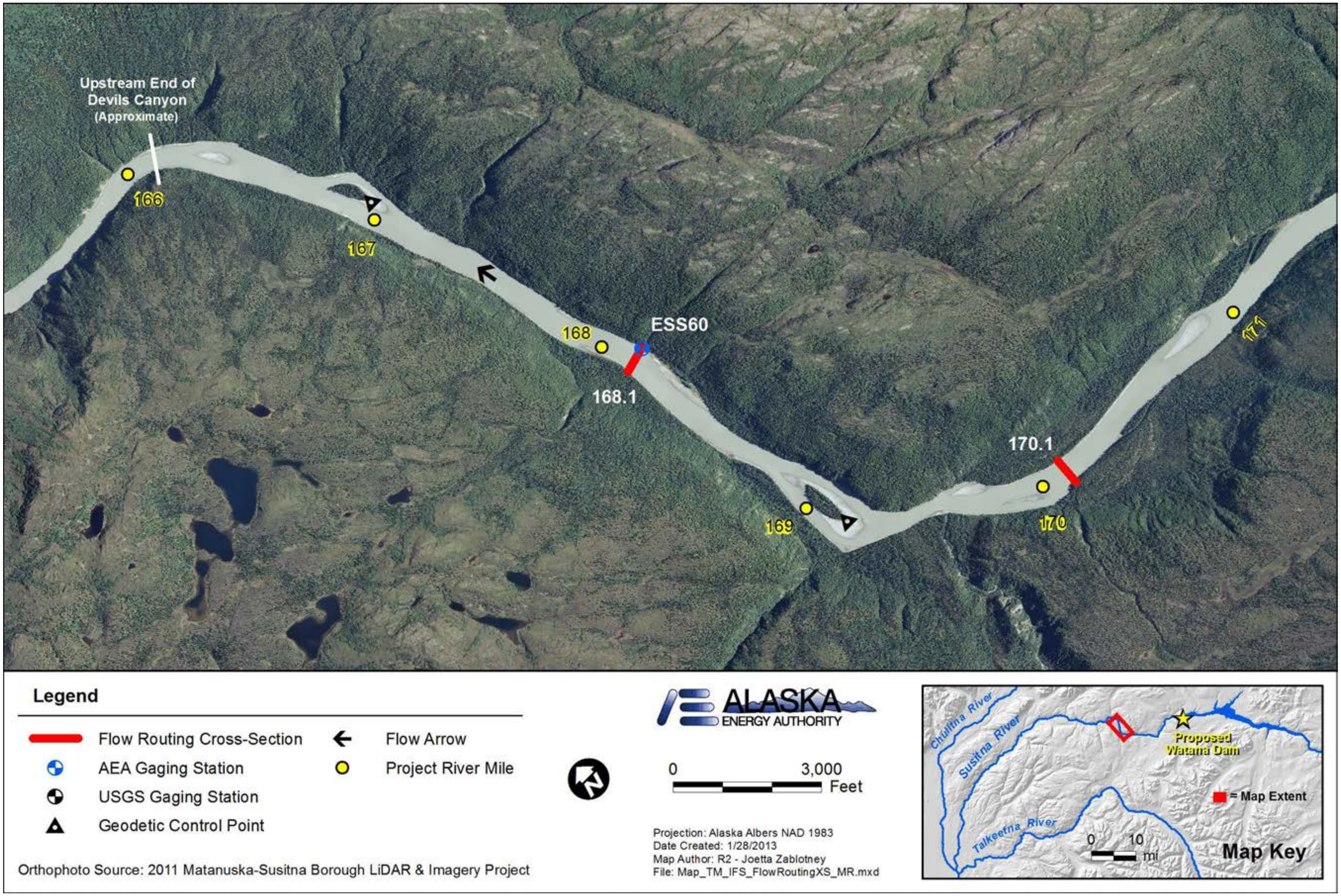


Figure 4.2-5. Maps of cross-section locations, survey control network benchmarks and gaging stations. The map covers the approximate river reach from PRM 171 down stream to PRM 168.

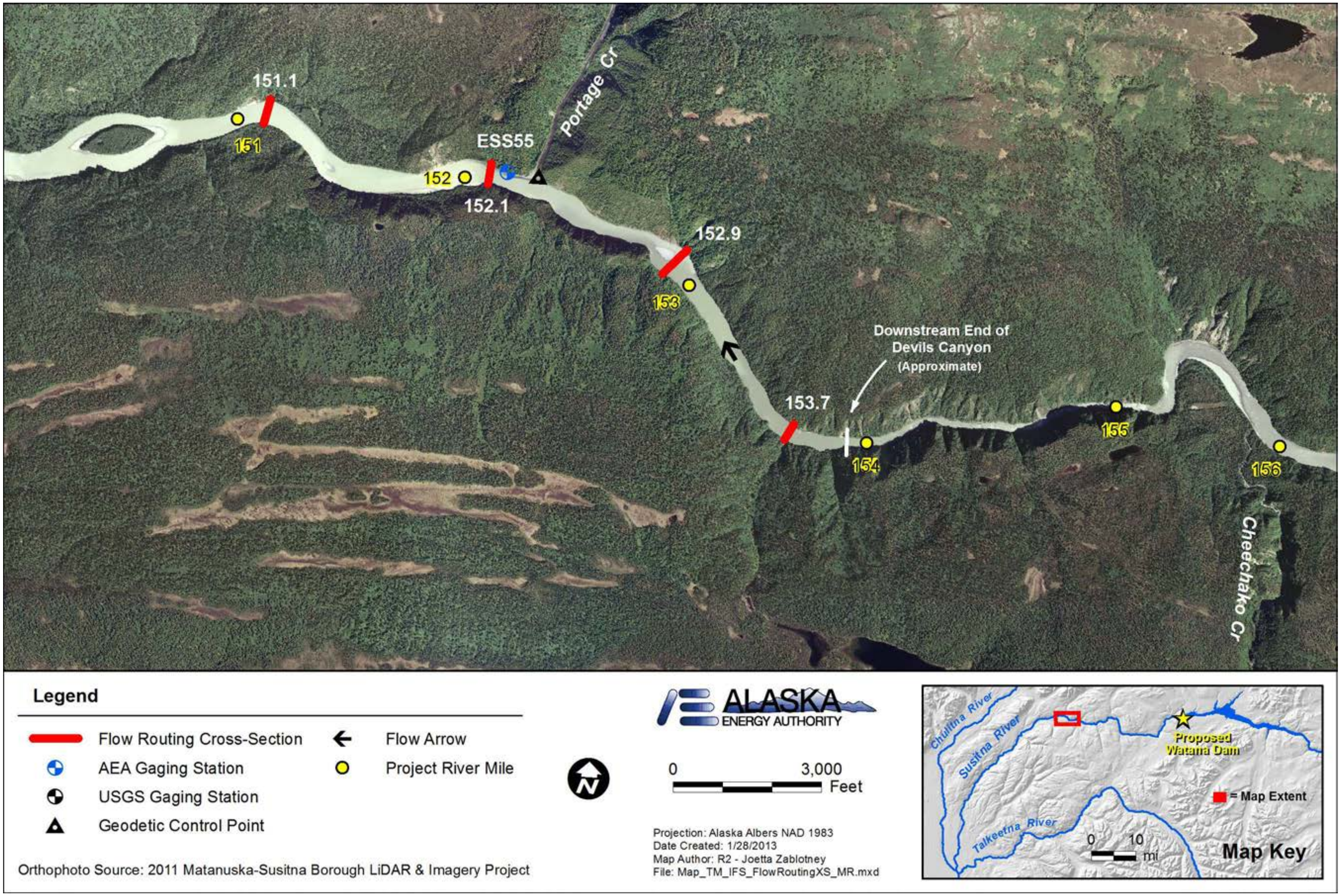


Figure 4.2-6. Maps of cross-section locations, survey control network benchmarks and gaging stations. The map covers the approximate river reach from PRM 156 down stream to PRM 151.

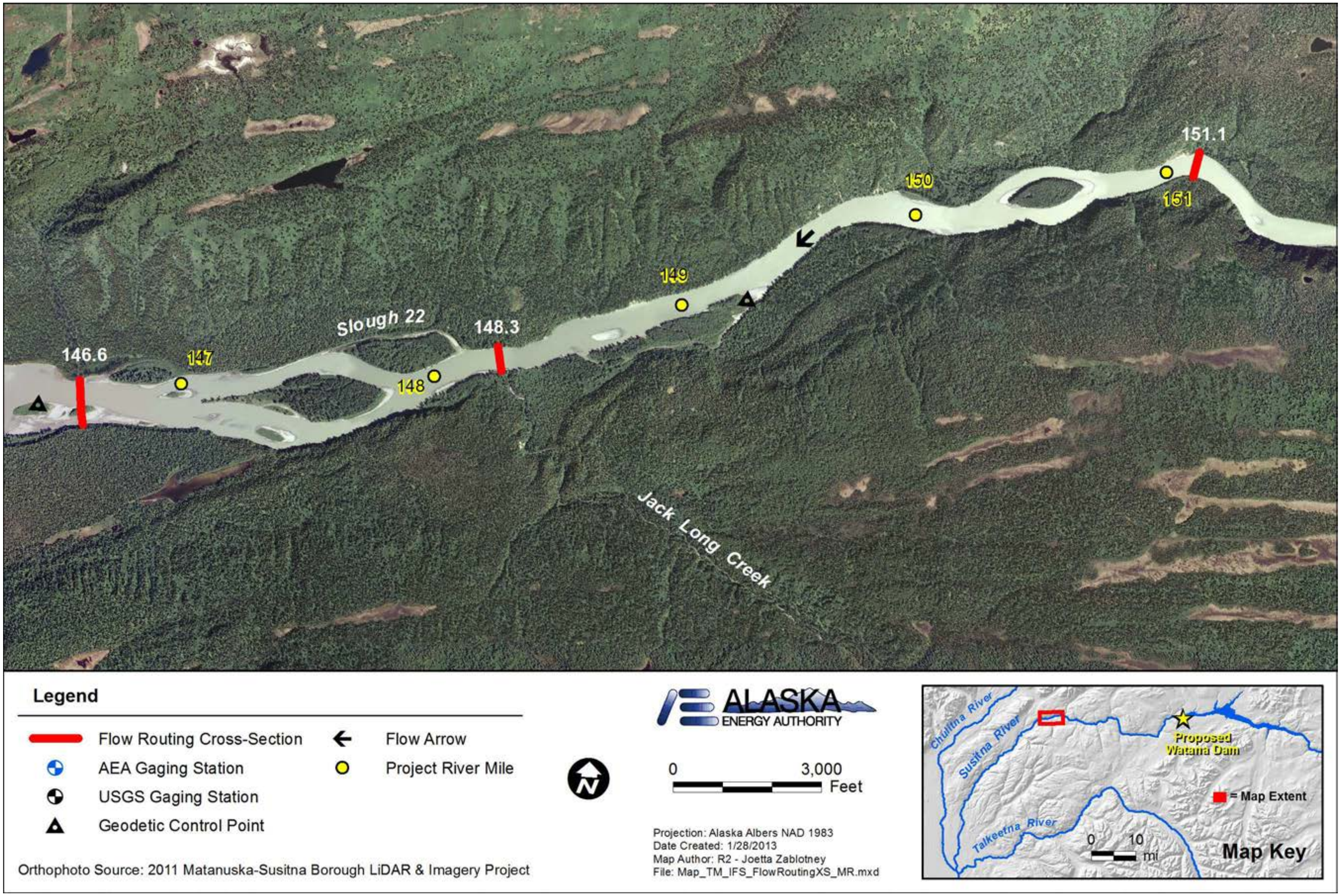


Figure 4.2-7. Maps of cross-section locations, survey control network benchmarks and gaging stations. The map covers the approximate river reach from PRM 151 down stream to PRM 147.

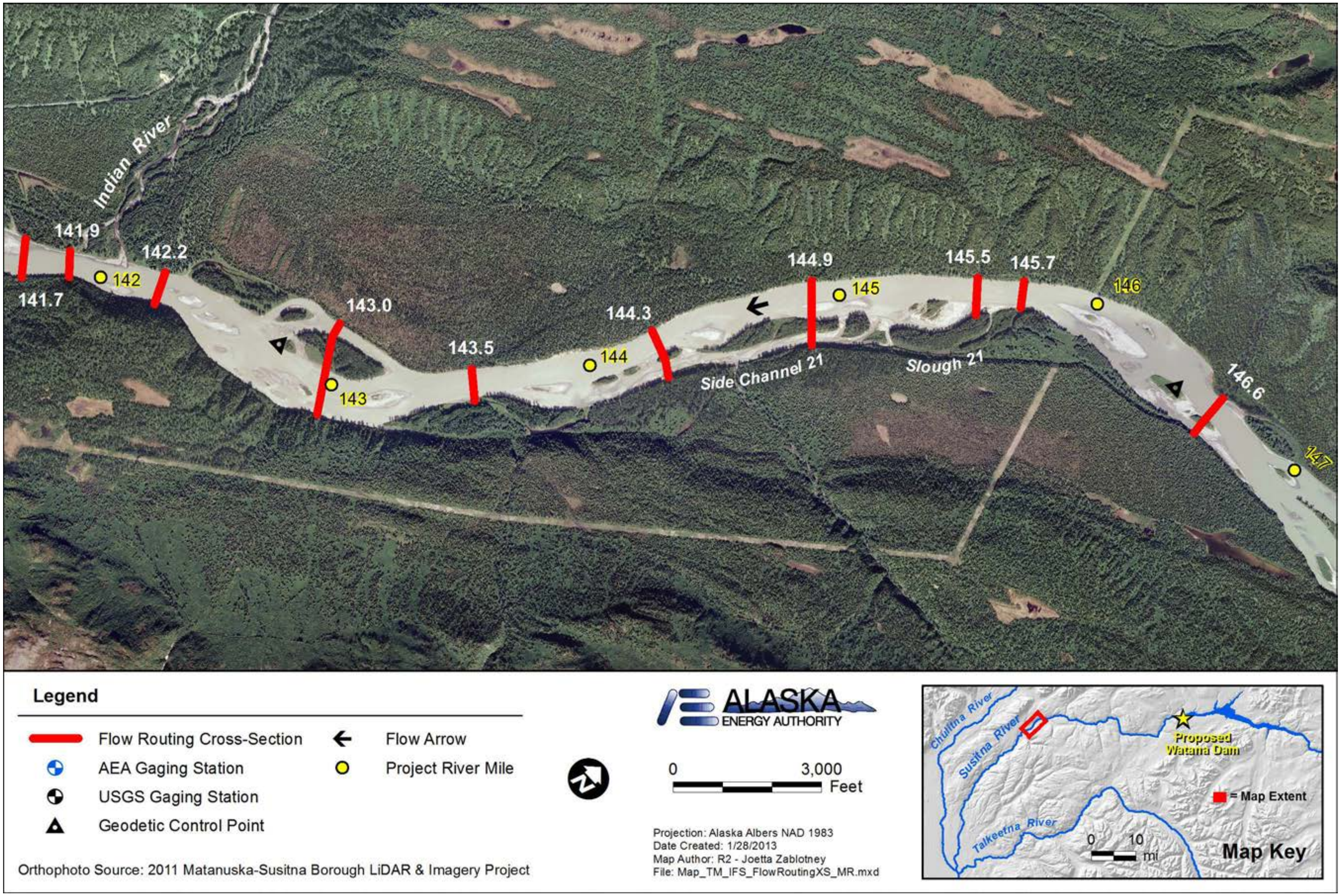


Figure 4.2-8. Maps of cross-section locations, survey control network benchmarks and gaging stations. The map covers the approximate river reach from PRM 147 down stream to PRM 142.

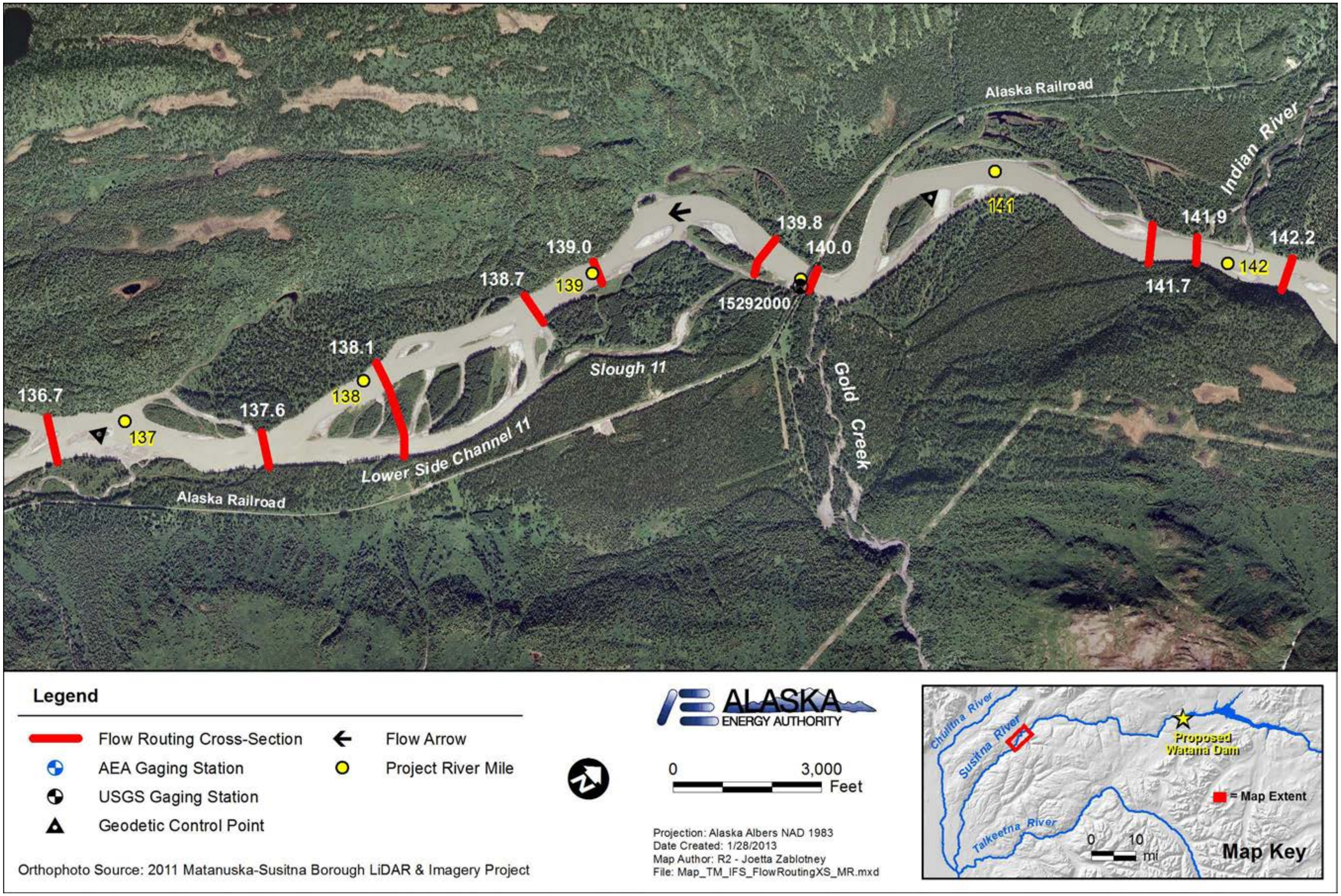


Figure 4.2-9. Maps of cross-section locations, survey control network benchmarks and gaging stations. The map covers the approximate river reach from PRM 142 down stream to PRM 137.

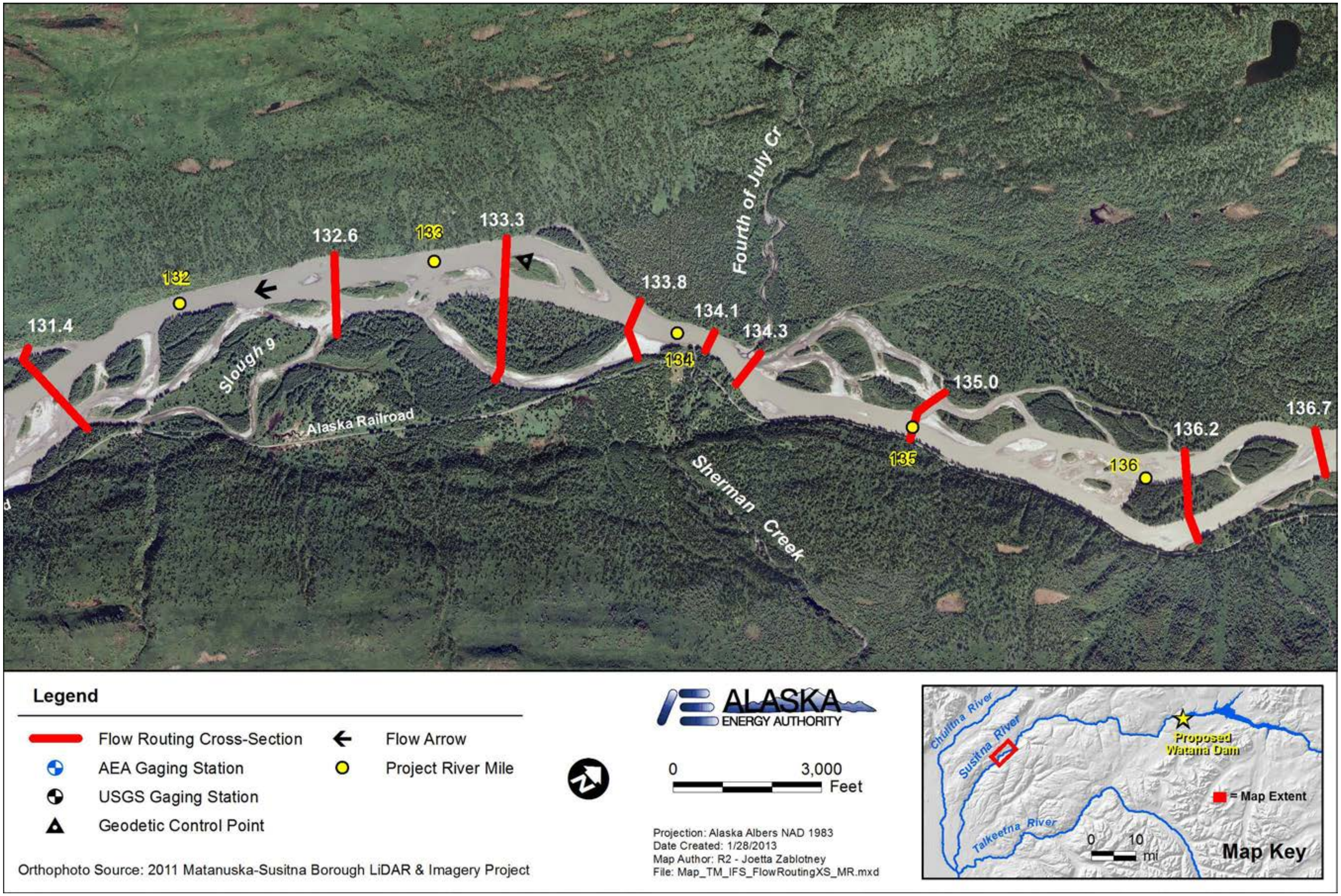


Figure 4.2-10. Maps of cross-section locations, survey control network benchmarks and gaging stations. The map covers the approximate river reach from PRM 137 down stream to PRM 132.

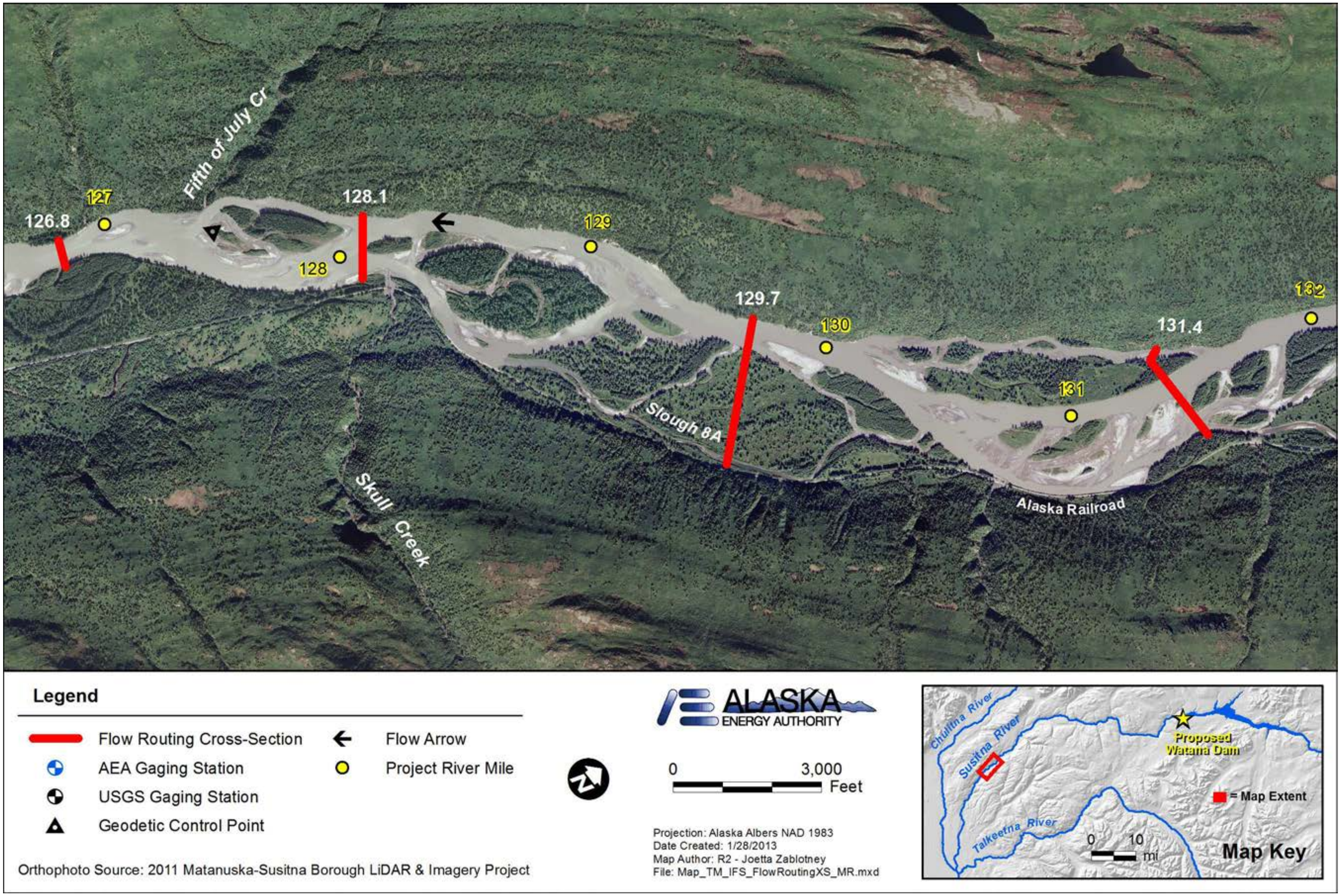


Figure 4.2-11. Maps of cross-section locations, survey control network benchmarks and gaging stations. The map covers the approximate river reach from PRM 132 down stream to PRM 127.

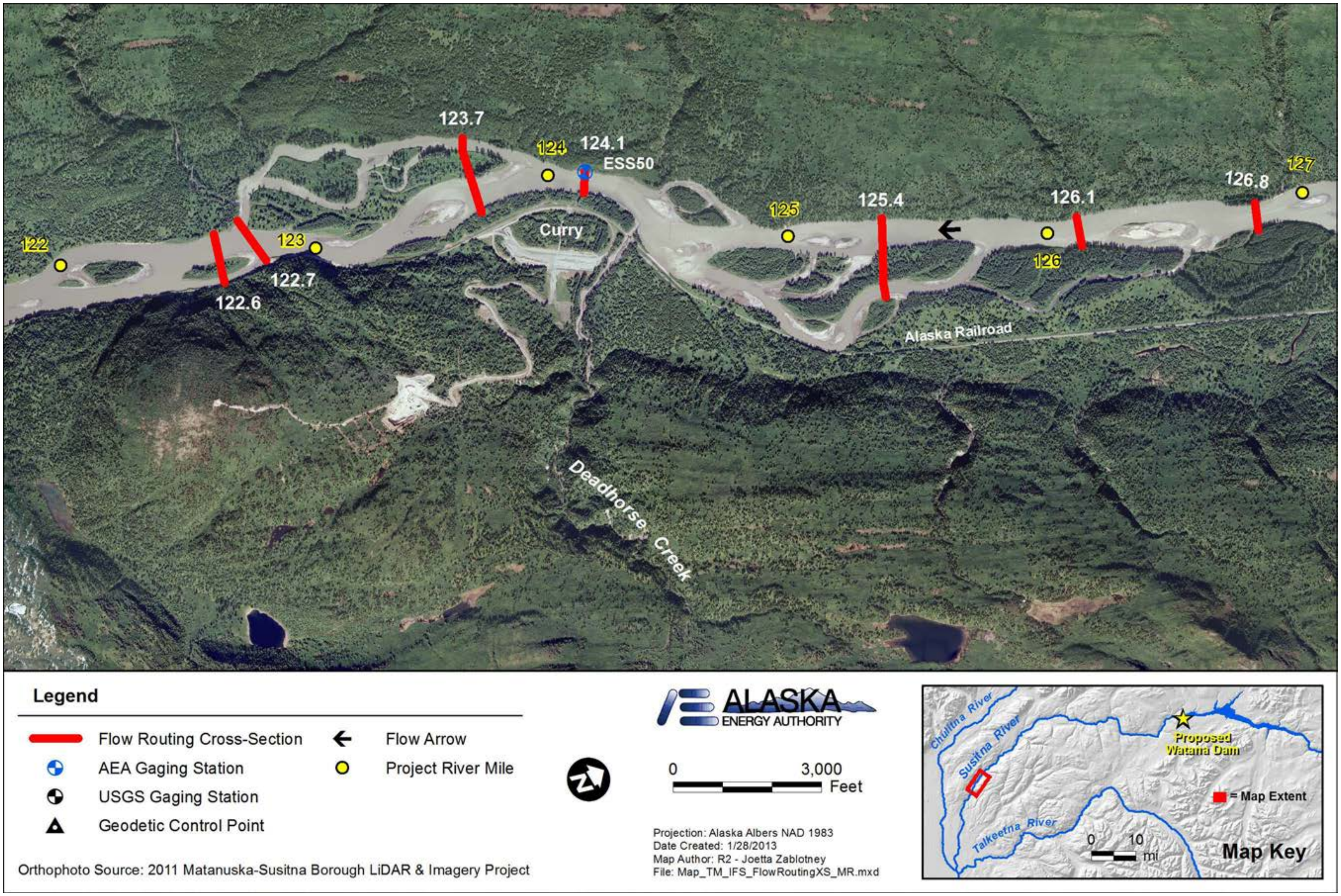


Figure 4.2-12. Maps of cross-section locations, survey control network benchmarks and gaging stations. The map covers the approximate river reach from PRM 127 down stream to PRM 122.

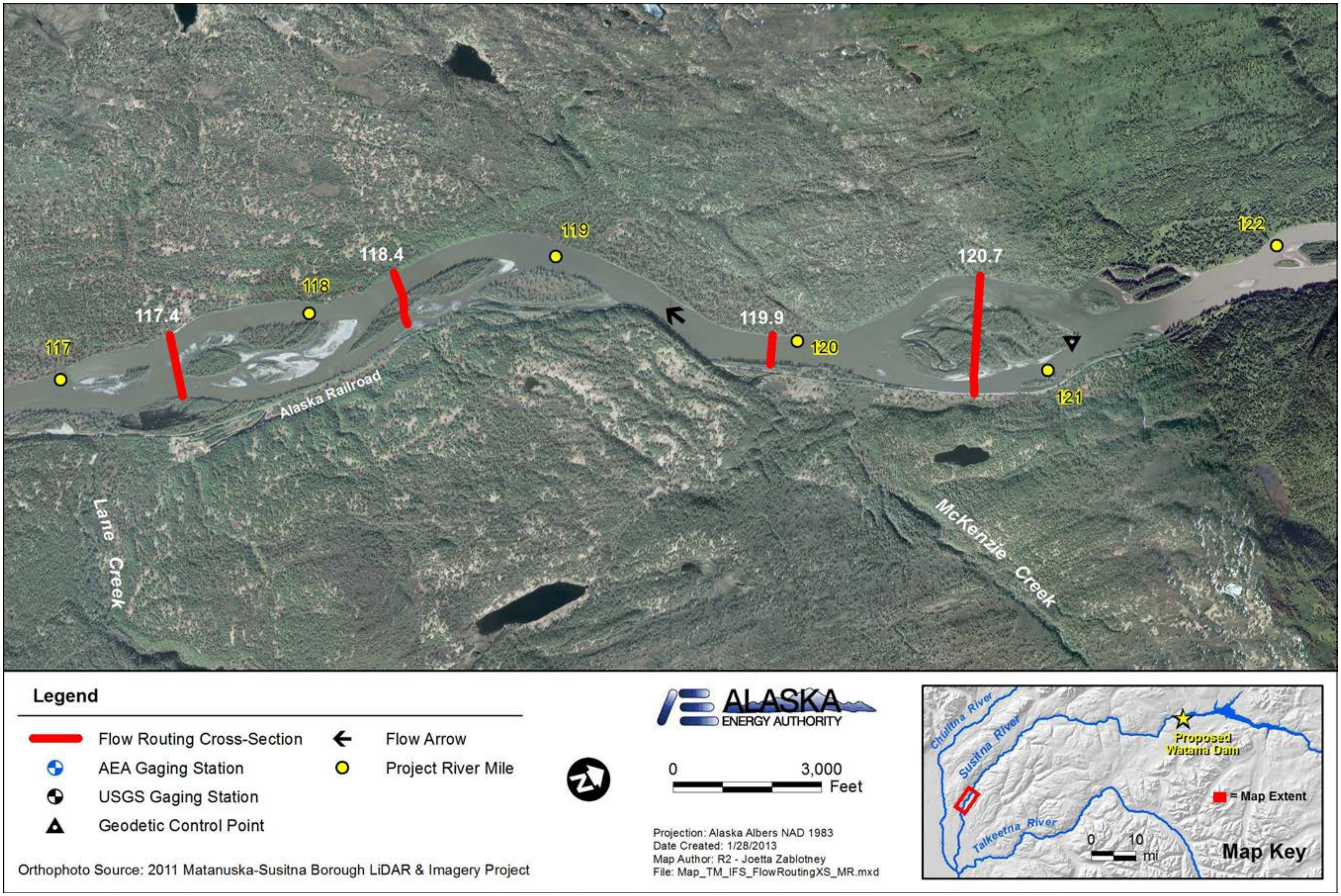


Figure 4.2-13. Maps of cross-section locations, survey control network benchmarks and gaging stations. The map covers the approximate river reach from PRM 122 down stream to PRM 117.

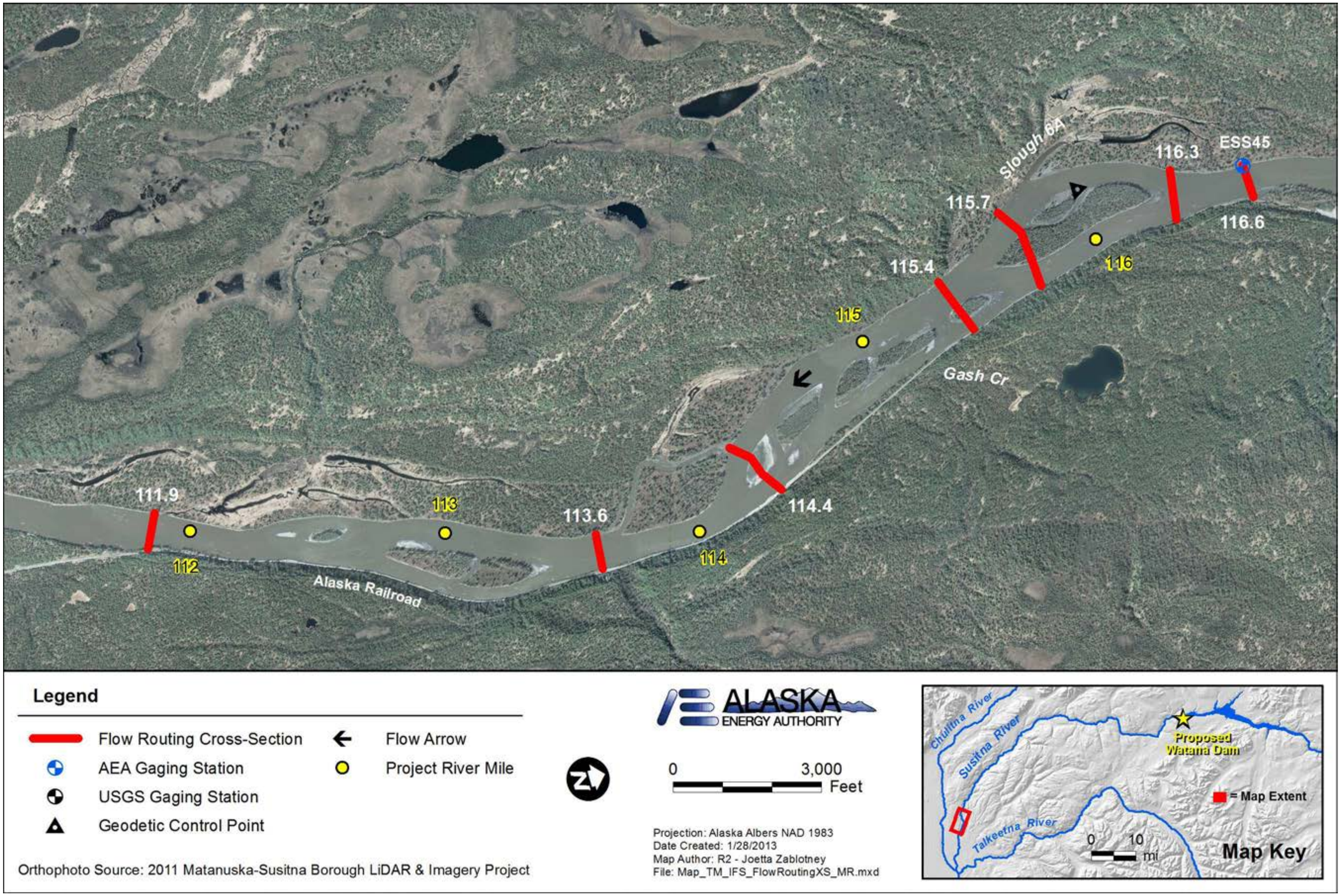


Figure 4.2-14. Maps of cross-section locations, survey control network benchmarks and gaging stations. The map covers the approximate river reach from PRM 117 down stream to PRM 112.

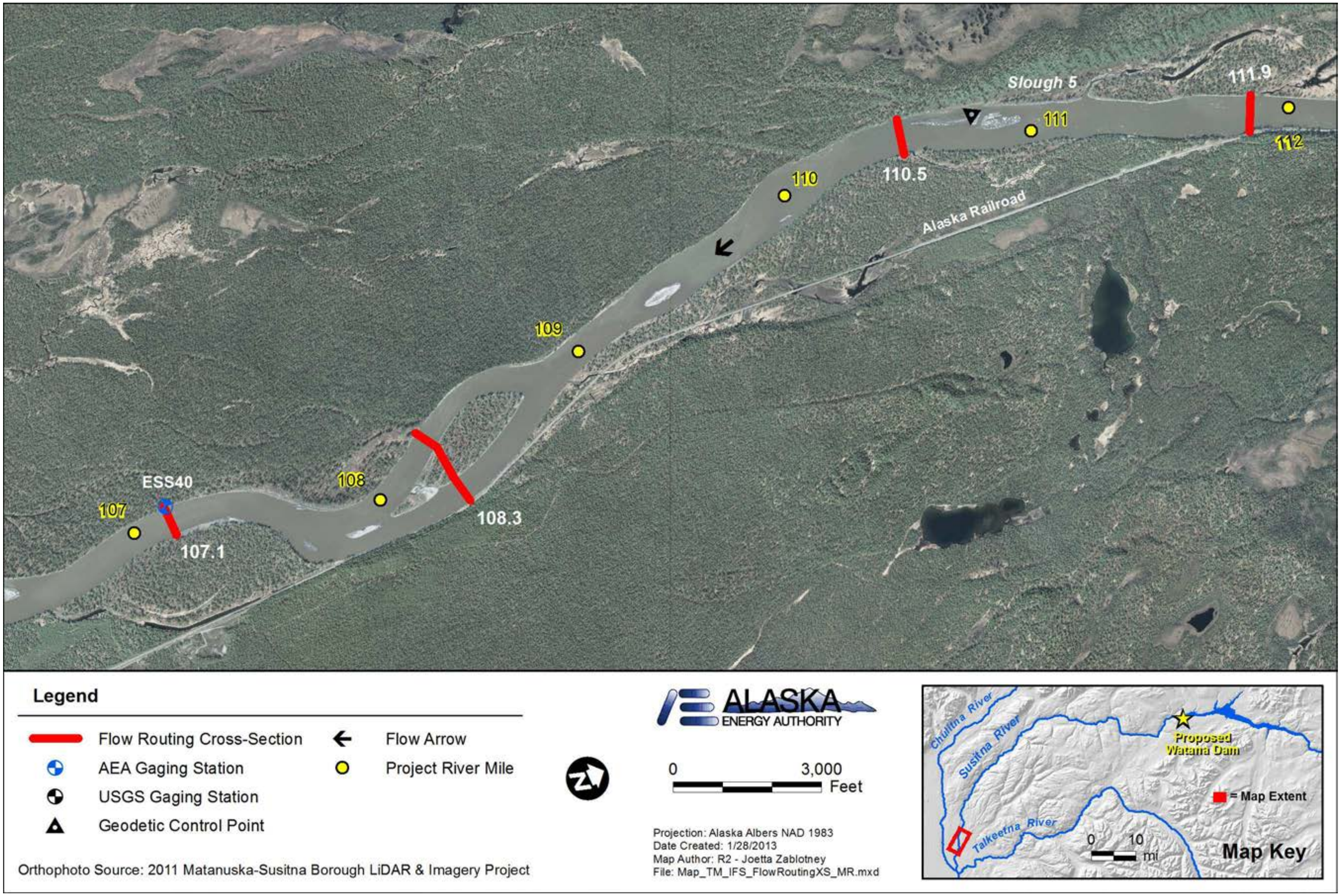


Figure 4.2-15. Maps of cross-section locations, survey control network benchmarks and gaging stations. The map covers the approximate river reach from PRM 112 down stream to PRM 107.

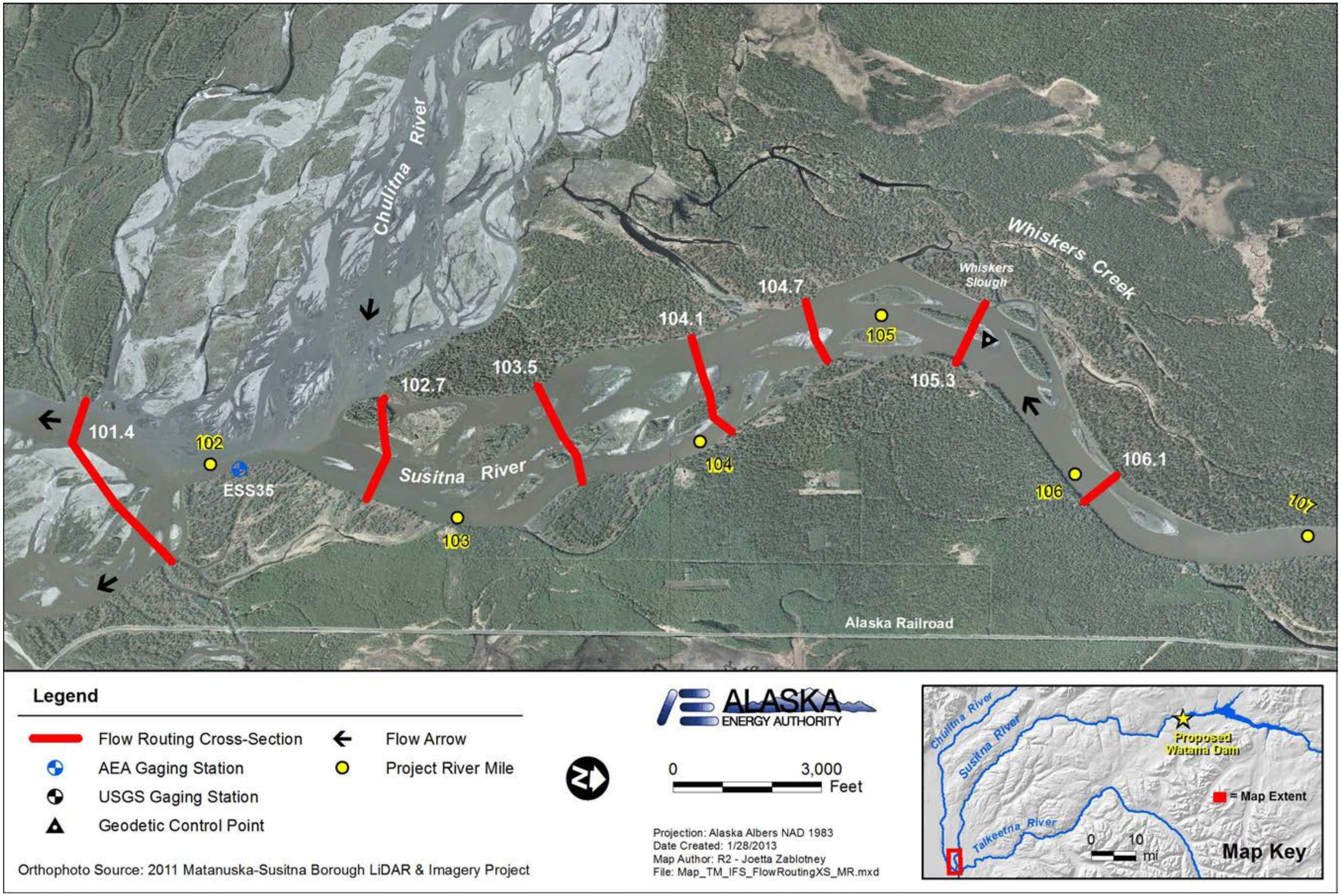


Figure 4.2-16. Maps of cross-section locations, survey control network benchmarks and gaging stations. The map covers the approximate river reach from PRM 107 down stream to PRM 102.

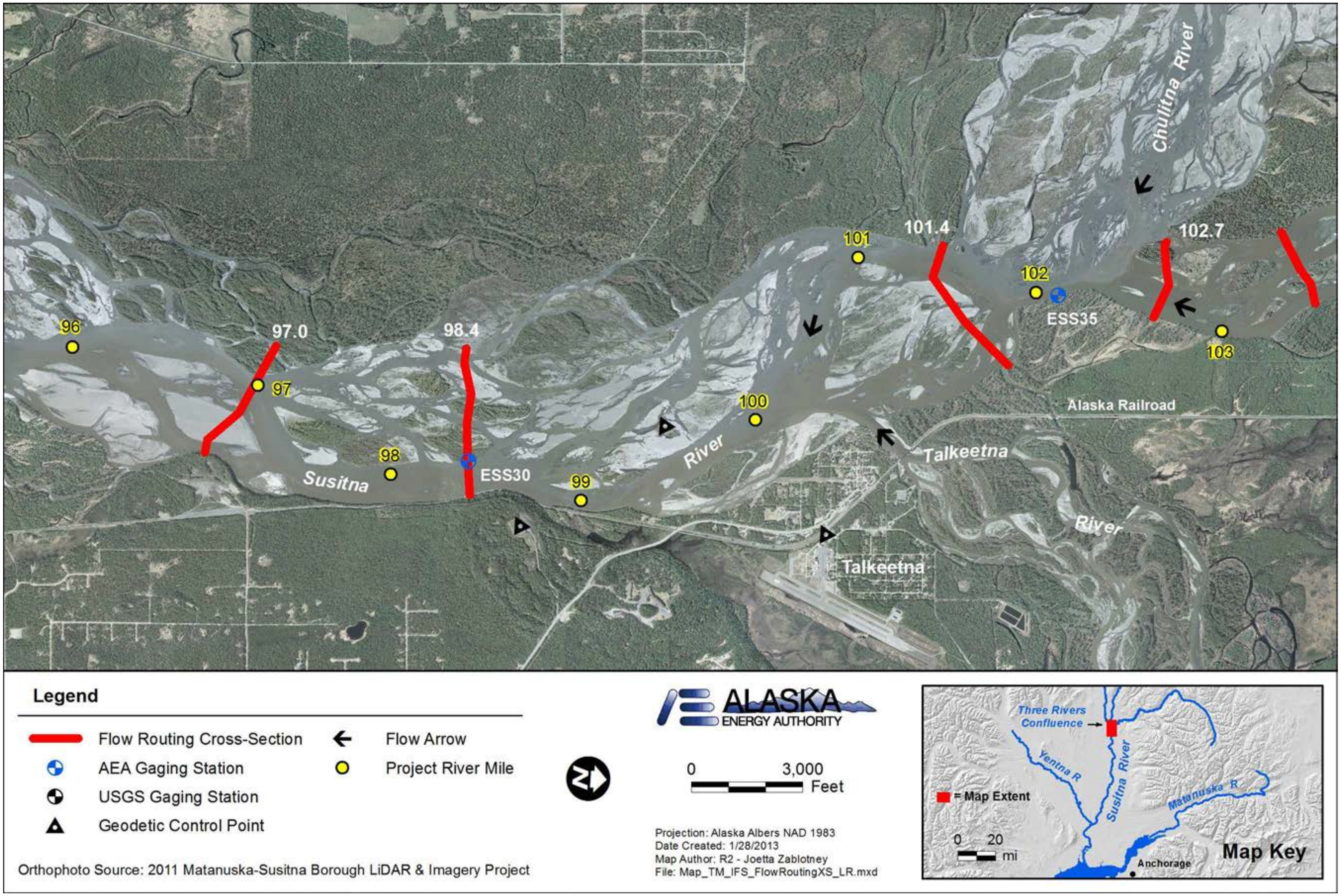


Figure 4.2-17. Maps of cross-section locations, survey control network benchmarks and gaging stations. The map covers the approximate river reach from PRM 103 down stream to PRM 98.

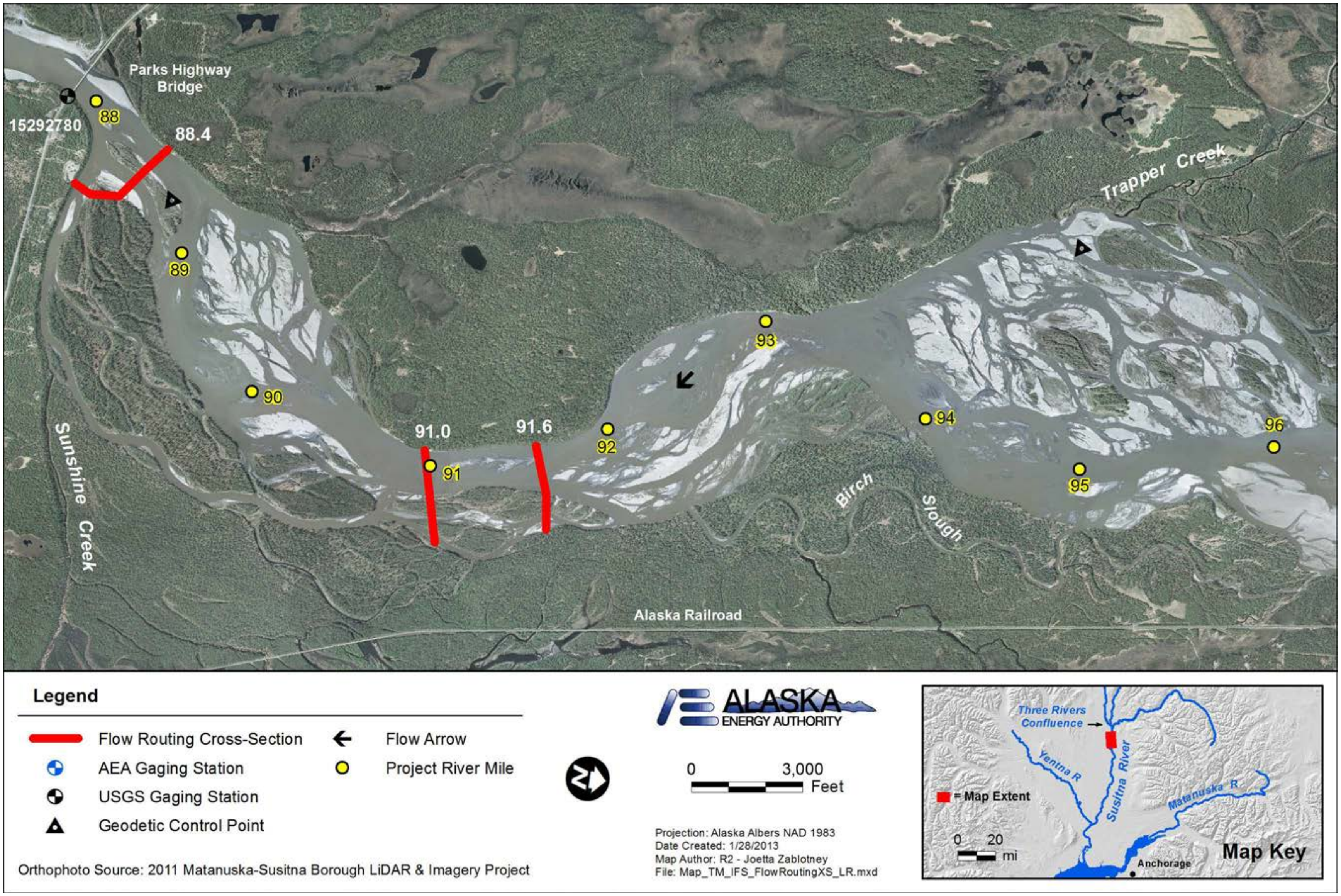


Figure 4.2-18. Maps of cross-section locations, survey control network benchmarks and gaging stations. The map covers the approximate river reach from PRM 96 down stream to PRM 88.

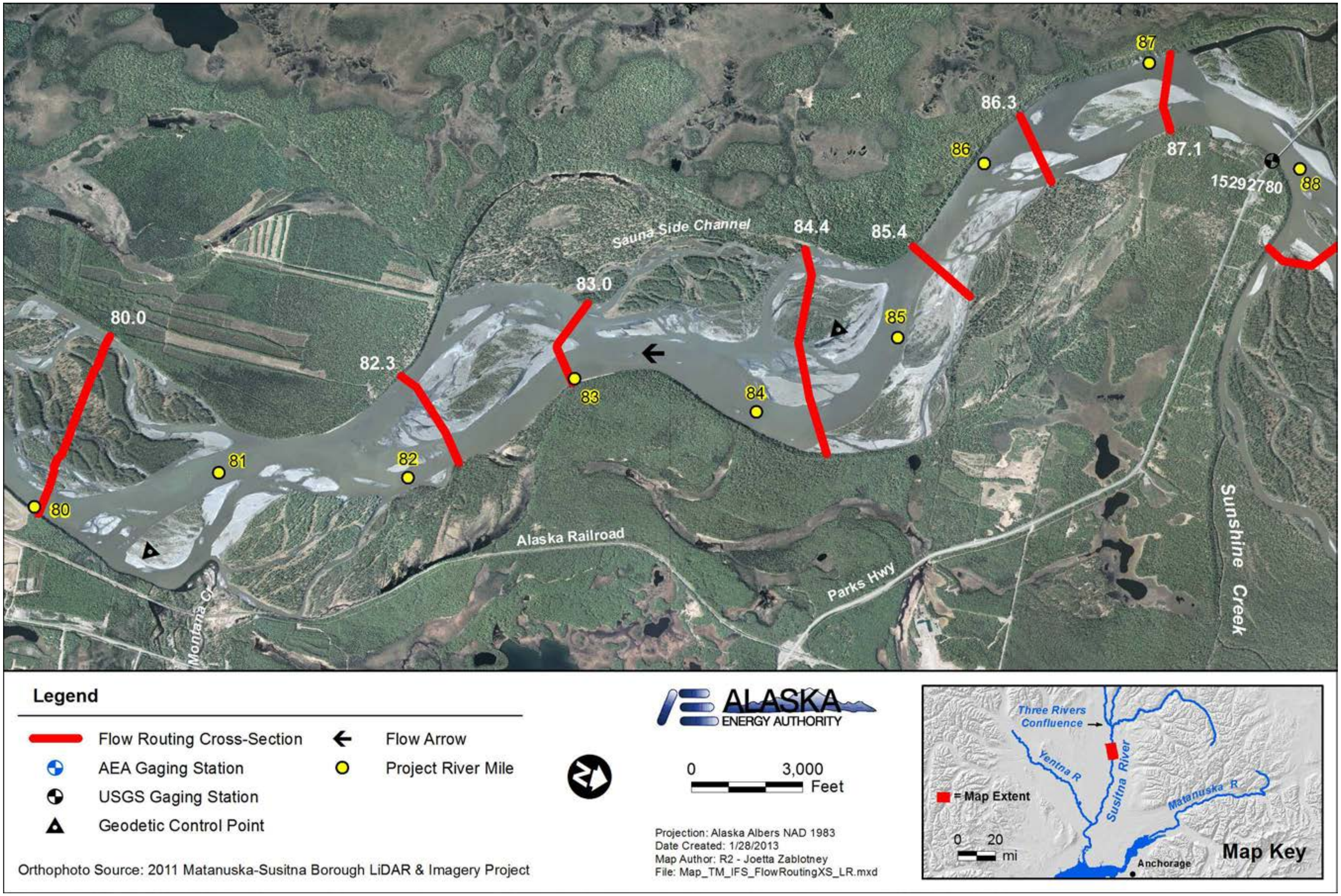


Figure 4.2-19. Maps of cross-section locations, survey control network benchmarks and gaging stations. The map covers the approximate river reach from PRM 88 down stream to PRM 80.

ATTACHMENT 1. DATA QUALITY ASSURANCE AND FINAL REPORTING STANDARDS SUMMARIES

SUSITNA-WATANA HYDROELECTRIC PROJECT

AEA Susitna Project 2012 – Instream Task2 Cross-Section and Task5 Network Studies

GPS Survey Network—Control Point Survey QC Protocol

Last Update: 20130104

Last Update By: Marielle Remillard, GW Scientific

Introduction

The F&A Program Lead team is tasked with implementing a standardized QA/QC protocol, intended for use in all environmental field studies in 2012, including fish and aquatic, water quality, river ice, terrestrial wildlife and botany, ISF, and others. This document will be presented to the leader and appointed Data Coordinator of each of these study teams.

Key Study staff for this data product:

- **Study Lead**: Steve Smith (Lead), Geovera
- **Field Survey Team Lead**: Billy Day, Geovera
- **Data Processing Staff**: Steve Smith (Lead), Geovera;
- **Data Coordinator**: Joetta Zablotney, R2 Resource Consultants
- **Data Resource Manager**: Dana Stewart, R2 Resource Consultants

QC Levels

There will be 5 levels of data QC, named QC1 to QC5. This allows for quick determination of the QC status of every data record. The first three levels are to be completed by the field study team, the fourth level by the Program Lead team, and the final level by senior professionals during analysis and reporting.

QC1 – Field Review: QC review performed by the person collecting field data, recorded in field books, and reviewed by the field team leader. The goal of QC1 is to identify errors and omissions and correct them under similar field conditions prior to leaving the field.

Review is done on 100% of data and includes completeness, legibility, and logic on all information recorded. This is typically completed in the field at time of survey; however, if outstanding conditions related to field team safety require that the team depart the survey site prior to completing QC1, QC1 shall be completed immediately upon arriving at an appropriate location.

Field book notations for static GPS observations shall contain the name of the person making the observations, the date, and a brief description of the weather. Notes for each control point observed shall contain a sketch of the monument markings, a sketch of the control point location, a handheld GPS position, a full description of the monument set or observed, the measure up from the monument to the receiver recorded in both feet and meters, the GPS receiver used for the static observation, and the name of the static observation file. At the end of the static GPS observation the measure up will be confirmed in the notes and a visual check of the optical plum will be made to verify that the receiver position did not change during the course of the observation.

At the end of each day the static observation files will be downloaded from the GPS receivers and put into an individual folder for that day's static GPS observations. The date of the observations shall be made a part of the folder name. The folder shall also contain electronic images (scan or photograph) of the field notes for each static observation and photographs of the control points and their immediate surroundings. The folders containing the record of the static observations will be transferred to the main office for post-processing.

QC2 – GPS Static Observation Post Processing: Static GPS observation files will be inserted into the GPS post-processing software. The autonomous positions of the observed control points will be checked against the handheld GPS positions to verify that the file names labeled in the field book match the file names brought into the post-processing software. The measure up for each control point will be confirmed by multiplying the distance recorded in meters by 3.280833 to confirm that it matches the distance recorded in feet. Each point will be given the name of the control point on which the static observations were conducted. This will insure that the reports containing the post-processing results clearly identify the control point for which the observations were made.

Post-processed points will be checked to insure that all results were fixed, and that the results meet the project requirements for observational precision. All points meeting the criteria for observational precision will be least-squares adjusted and a report will be generated outlining all of the post-processing and adjustment results.

Coordinates of the control points will be exported to an ascii file which will be stored in that day's static observation folder. The post processing report will be saved to PDF format and stored in the folder along with the post-processing software file, the GPS static observation files, control point photographs, and the field note images.

The goal of QC2 is to verify correct, complete, and consistent data entry, but it is also an opportunity to compare previous independent observation results with current observation results. During QC2, previous observations will be referenced to determine whether or not there are any discrepancies between a previous and current control point position. A note can be added to the electronic survey sheet regarding this movement. However, the position of a primary monument shall not be adjusted until QC3.

Data Entry Study Staff: Steve Smith (Lead), Geovera

QC3 – Senior Review: Data is reviewed by a senior professional on the project team, checking for logic, soundness, and adding qualifiers to results if warranted. Coordinates of project control points will be placed in a spreadsheet for final posting to the wiki. The spreadsheet will contain the point number, date of the static observations, latitude and longitude (in decimal degrees), Alaska State Plane Zone 4 coordinates, elevation and point descriptor of each of the project control points. In addition, there will be a statement of precision that each of the control point's static observations fall within, as determined from the post-processing results. The spreadsheet will contain a header that labels the contents, date of last entry, person responsible for the data entry, as well a statement about the datum (WGS84/NAD83), Alaska state plane zone (4), and geoid (09) used to determine the orthometric heights (elevations) of the points.

All data will be entered into electronic format directly, either by importing the data directly from an ascii file, or cutting and pasting directly from and to electronic files. No coordinate data will be hand entered (typed with a keyboard). This is to eliminate the possibility of erroneously transposing numbers. Once all data has been entered into the spreadsheet, the data fields will be cross-checked directly against the original GPS post-processing files to insure their accuracy.

Senior Review Study Staff: Steve Smith (Lead), Geovera

QC4 – Database Validation: Electronic data files are submitted to the Program Lead's data resources manager. The deadline for this delivery is negotiated with the team Data Coordinator in consideration of the study due date.

Further QC4 verification of data isn't applicable to Control Point Survey data.

Data Coordinator: Joetta Zablotney, R2 Resource Consultants

QC5 – Technical Review: Data revision and qualification may be applied by senior professionals when analyzing data for reports, trends, and FERC applications. Data calculations may be stored with the data. Some data items may get corrected or qualified within the database, while others are only addressed in report text. QC5 may be iterative, as data are analyzed in multiple years.

If a data item is revised directly, it's recorded in 2 columns of the Control Point Survey Log: QC5 (date and staff) and QC5Edit (what is revised and why). Additionally, the date and data coordinator should be updated in the file name when appropriate. This will serve as adequate documentation of the revisions, so maintenance of additional documentation isn't usually necessary. QC5 revisions should not be made until reviewed and accepted by the Lead Surveyor or Study Lead if he is not available. The data will be changed in final Project files, and the Data Resource Manager notified.

Field Data Backups

Both paper and electronic field forms should be backed up nightly in the field by scanning and downloading to a storage unit or photocopy to paper. Field notes books and electronic files are posted to the Study Internal Wiki sites where appropriate.

Data Revisions

Once the processed field data (QC3) have been submitted by the Study Lead (Michael Lilly) to AEA via R2 (Joetta Zablotney), and it has been validated as ready for incorporation into the Susitna project data collection (QC4), the data are considered to reside with AEA, and subsequent revisions will be made in a manner determined to be appropriate by the Program Lead team or AEA at the time. If a study team discovers that data require revisions, their Data Coordinator can send a formal, written request (i.e. email) to the Data Resources Manager. Revisions will be made and the appropriate QC columns updated, which will serve as adequate documentation.

Data Deliverables

The following information describes the intermediate and final data deliverable for the Study control point survey data. QC1 information is primarily recorded in the field and then field notebooks are scanned and stored on the Task 2 Wiki site. The QC2 files are saved on the Task2 Internal Wiki site until level QC3 is complete. Once Level QC3 is complete, the files will be made available to other study teams on the Task 5 wiki site. At this stage, the Excel survey data files will be made available to the Program Lead's data resources manager.

Data files will be submitted following the Project standards for data deliverables. The following subdirectory and file naming structures will be used.

Excel Files:

Subdirectory Descriptor	Format / Example
Project Name	SuWa (Level 1)
Submitting Consultant	GWS (Level 1)
Program Name	FA-IFS (Level 2)
Study Subject	XSection (Level 2)
Beginning Study Date	20120601 (Level 2)
Final Deliverable	GPS Control Survey Network (Level 3)
Filename Descriptor	**Format / Example**
Program Name	FA-IFS
Study Subject	XSection
Data Type	Susitna Control Geodetic
Date Last Updated	YYYYMMDD
File Type	.xlsx (most recent versions of Excel (2007 to 2013))

Example: SuWa_GWS\FA-IFS_XSection_20120601\ GPS Control Survey Network \
FA-IFS_XSection_Susitna_Control_Geodetic_20121029.xlsx

Notes:

- DO NOT use spaces or special characters in subdirectory (folder) and file names
- File naming convention is to allow files to indicate content when stand alone and not in the submitted subdirectory.

SUSITNA-WATANA HYDROELECTRIC PROJECT

AEA Susitna Project 2012 – Instream Task2 Cross-Section and Task5 Network Studies

GPS Survey Network – Control Point Photos: Data QC Protocol

Last Update: 20130104

Last Update By: Marielle Remillard

Introduction

This document is intended to cover the data processing, quality control (QC), and final reporting for the GPS Survey Control Network photographs (photos) of control points (cp). The cp photos will be a final deliverable along with the final cp survey data. The separation of the cp photo data processing is to allow it to be processed separately.

Key Study staff for this data product:

- **Study Lead**: Michael Lilly, GW Scientific
- **Field Survey Team Lead**: Billy Day, Geovera
- **CP Photo Processing Staff**: Marielle Remillard (Lead), Martha Ballard; GW Scientific
- **Data Coordinator**: Joetta Zablotney, R2 Resource Consultants
- **Data Resource Manager:** Dana Stewart, R2 Resource Consultants

There will be 5 levels of data QC, named QC1 to QC5, each of which is tracked within the cp photo catalog (FA-IFS_XSection_GPS_CP_Photos_Network_PhotoLog_YYYYMMDD). This allows for quick determination of the QC status of every cp photo data record. The first three levels are to be completed by the field study team, the fourth level by the Program Lead team, and the final level by senior professionals during analysis and reporting.

QC1 – Field Review: QC review performed by the person collecting cp photo data, recorded in field books, and then by the field team leader. The goal of QC1 is to save image files and back them up in an organized format prior to leaving the field. Review is done on 100% of cp photo data and includes accurate organization of the photos on all information recorded. This is typically completed in the end of the day for each survey event.

QC2 – Data Entry: CP photo data are organized by cp location and renamed accordingly to the Project naming convention listed below. The goal of QC2 is to correctly rename the cp photos so they can later be used by Project studies to help locate cp's in the field.

Verification is done on 100% of cp photo data entered and includes extrapolation of shorthand codes that might be used in the field into longhand or standard codes during cp photo renaming. CP photo data renaming errors are corrected at this time, then QC is recorded in the photo catalog column named “QC2”, containing the date and responsible staff as formatted as “YYYYMMDD FLastname” (example: “20120915 MRemillard”).

Data Entry Study Staff: Daniel Reichardt (Lead), Marielle Remillard, Martha Ballard, GW Scientific

QC3 – Senior Review: CP photo data are reviewed by a senior professional on the project team, checking for logic, soundness, and adding qualifiers to results if warranted. Q3 is the step where the photo location is verified. This is the final review before submitting cp photo data to the Program Lead, and is recorded in the photo catalog “QC3” column in the same format as QC2. This is also the QC level of raw files that have been “cleaned up” or otherwise processed for delivery to AEA.

Senior Review Study Staff: Billy Day (Lead), Geovera, or Michael Lilly, GW Scientific, Daniel Reichardt, GW Scientific

QC4 – Database Validation: Electronic cp photo data files are submitted to a photo catalog by the Program Lead’s data resources manager. The deadline for this delivery is negotiated with the team Data Coordinator in consideration of the study due date.

QC4 of photos will verify that file naming matches project standards and the task naming convention listed below. It will not verify photo contents against the file names or descriptive attributes within the catalog. QC4 of the photo catalog will be done as needed to incorporate it into a comprehensive photo catalog for the project. This involves verification of field name conventions, date formats, etc., splitting it into normalized tables as necessary and establishing primary and foreign keys. If any errors are detected, an error report is generated for the study team lead, who is expected to make corrections and resubmit data. The process is repeated until verification is clean and records are marked in the photo catalog column “QC4” (such as “20121001 DStewart”).

Program Lead’s Data Resource Manager: Dana Stewart, R2 Resource Consultants

QC5 – Technical Review: Photo content should not be altered during technical review. Qualification of photos or attributes within the catalog may be applied by senior professionals when analyzing data for reports, trends, and FERC applications. Some data items may be corrected or qualified within the database photo catalog itself, while others are only addressed in report text.

Notes pertaining to cross section photo data item are recorded in 2 columns: QC5 (date and staff) and QC5Edit (what is changed and why). This will serve as adequate documentation of the qualifications, so maintenance of additional documentation isn't usually necessary. QC5 revisions will be physically made by the Data Resource Manager, directed by the senior professional.

Field Data Backups

Field photos should be backed up nightly from cameras to field laptops and USB drives. The cp photos should then be placed by supporting field staff onto the Study Task2 internal wiki site for access by other study staff.

Data Revisions

Once the processed cp photo data (QC3) have been submitted by the Study Lead (Michael Lilly) to AEA via R2 (Joetta Zablotney), and it has been validated as ready for incorporation into the Susitna project database (QC4), the data are considered to reside with AEA, and subsequent revisions will only be made by the Program Lead team on their behalf. If a study team discovers that data require revisions, their Data Coordinator (Joetta Zablotney) can send a formal, written request (i.e. email) to the Data Resources Manager. Revisions will be made and the appropriate QC columns updated in the photo catalog, which will serve as adequate documentation.

Data Deliverables

The following information describes the intermediate and final data deliverable for the Study cp photo data. QC1 information is primarily recorded in the field or field office when images are downloaded and organized. CP photos are then stored on the Task 2 Wiki site for study staff access. The QC2 level files are saved on the Task2 Internal Wiki site until level QC3 is complete. Once Level QC3 is complete, the files will be made available to other study teams on the Task 5 wiki site. At this stage, the Excel photo index files and cp photo files will be made available to the Program Lead's data resources manager on a USB flash drive with transmittal memo.

The JPG files will be submitted following the Project standards for data deliverables. The following subdirectory and file naming structures will be used.

Subdirectory Descriptor	Format / Example/ (Subdirectory level)
Project Name	SuWa (Level 1)
Submitting Consultant	GWS (Level 1)
Program Name	FA-IFS (Level 2)
Study Subject	XSection (Level 2)
Beginning Study Date	20120601 (Level 2)

Final Deliverable	GPS Control Survey Network (Level 3)
Control Point Name	CPxxx (ex: CP99, CP101) (Level 4)
Data Type	Survey_Control_Network_Photos (Level 4)
Filename Descriptor	Format / Example
Program Name	FA-IFS
Study Subject	XSection
Data Type	Survey_Control_Network
QC Level	QC2 or QC3
Control Point Name	CPxxx (ex: CP99, CP101)
Survey Date (Photo Date)	YYYYMMDD (ex: 20120610)
Original Photo Name	DC12345 (varies by camera and user)
File Type	.jpg (image file format)

Example:
SuWa_GWS\FA-IFS_XSection_20120601\ GPS_Control_Survey_Network\
CP101_Survey_Control_Network_Photos\FA-
IFS_XSection_Survey_Control_Network_QC2_CP101_20120610_DC12345.jpg

Notes:

- DO NOT use spaces or special characters in subdirectory (folder) and file names
- File naming convention is to allow files to indicate content when stand alone and not in the submitted subdirectory
- Images are kept in their original resolution taken by the camera

SUSITNA-WATANA HYDROELECTRIC PROJECT

AEA Susitna Project 2012 – Instream Task2 Cross-Section and Task5 Network Studies

GPS Survey Network—RTK Survey QC Protocol

Last Update: 20130111

Last Update By: Marielle Remillard, GW Scientific

Introduction

The F&A Program Lead team is tasked with implementing a standardized QA/QC protocol, intended for use in all environmental field studies in 2012, including fish and aquatic, water quality, river ice, terrestrial wildlife and botany, ISF, and others. This document will be presented to the leader and appointed Data Coordinator of each of these study teams.

Key Study staff for this data product:

- **Study Lead**: Steve Smith (Lead), Geovera, LLC
- **Field Survey Team Lead**: Billy Day, Geovera, LLC
- **Data Processing Staff**: Steve Smith (Lead), Geovera, LLC
- **Data Coordinator**: Joetta Zablotney, R2 Resource Consultants
- **Data Resource Manager**: Dana Stewart, R2 Resource Consultants

QC Levels

There will be 5 levels of data QC, named QC1 to QC5. This allows for quick determination of the QC status of every data record. The first three levels are to be completed by the field study team, the fourth level by the Program Lead team, and the final level by senior professionals during analysis and reporting.

QC1 – Field Review: QC review performed by the person collecting field data, recorded in field books, and reviewed by the field team leader. The goal of QC1 is to identify errors and omissions and correct them under similar field conditions prior to leaving the field.

Review is done on 100% of data and includes completeness, legibility, and logic on all information recorded. This is typically completed in the field at time of survey; however, if outstanding conditions related to field team safety require that the team depart the survey site prior to completing QC1, QC1 shall be completed immediately upon arriving at an appropriate location.

GPS Static Control

Field book notations for static GPS observations shall be in accordance with the Susitna-Watana Project Geodetic Control Standards. Notes for each occupation will be checked to insure that the following information is included:

1. The beginning and ending times for the occupation.
2. The name of the surveyor performing the occupation.
3. The receiver identifier (make, model, serial number).
4. The centering device identifier.
5. All antenna height measurements (in meters and feet).
6. The station identifier (name and/or survey point number).
7. A description of the monument and center mark.
8. Monument photograph/rubbing.

At the end of each day the static observation files will be downloaded from the GPS receivers and put into an individual folder for that day's static GPS observations. The date of the observations shall be made a part of the folder name. The folder shall also contain electronic images (scan or photograph) of the field notes for each static observation and photographs of the control points and their immediate surroundings (if any). The folders containing the record of the static observations will be transferred to the main office for post-processing.

RTK Surveying

Field book notations for RTK (Real Time Kinematic) observations shall be in accordance with the Susitna-Watana Project Geodetic Control Standards. Occupation of the reference control (base) stations will be in accordance with the procedures described for GPS static control above.

RTK data collected is electronically stored in a "data collector". Occupation data and point descriptors are entered manually for RTK surveyed points. In addition, descriptors of the RTK points are noted in the field book. If multiple observations are made on a point (typically a survey monument or similar point of special interest), a note will be made in the field book as to which of the observations had the best residuals.

Each day, the data collector files will be downloaded and electronically stored as part of the permanent job record. Data collector files contain all of the observation and occupation data for each RTK data point, as well as coordinate data and point descriptors. Field notes for the day's work will be scanned into electronic format and made a part of the permanent job record.

QC2 – GPS Static Observation Post Processing: Static GPS observation files will be inserted into the GPS post-processing software. The measure up for each control point will be confirmed by multiplying the distance recorded in meters by 3.280833 to confirm that it matches the distance recorded in feet. Each point will be given the name of the control point on which the static observations were conducted. This will insure that the reports containing the post-processing results clearly identify the control point for which the observations were made.

Post-processed points will be checked to insure that all results were fixed, and that the results meet the project requirements for observational precision. All points meeting the criteria for observational precision will be least-squares adjusted and a report will be generated outlining all of the post-processing and adjustment results.

Coordinates of the control points will be exported to an ASCII file which will be stored in that day's static observation folder. The post processing report will be saved to PDF format and stored in the folder along with the post-processing software file, the GPS static observation files, control point photographs, and the field note images.

The goal of QC2 is to verify correct, complete, and consistent data entry, but it is also an opportunity to compare previous independent observation results with current observation results. During QC2, previous observations will be referenced to determine whether or not there are any discrepancies between a previous and current control point position. A note can be added to the electronic survey sheet regarding any positional differences. However, the position of a primary monument shall not be adjusted until QC3.

Data Entry Study Staff: Steve Smith (Lead), Geovera

QC3 – Senior Review: Data is reviewed by a senior professional on the project team, checking for logic, soundness, and adding qualifiers to results if warranted. Coordinates of project control points will be placed in a spreadsheet for final posting to the wiki. The spreadsheet will contain the point number, date of the static observations, latitude and longitude (in decimal degrees), Alaska State Plane Zone 4 coordinates, elevation and point descriptor of each of the project control points. In addition, there will be a statement of precision that each of the control point's static observations fall within, as determined from the post-processing results. The spreadsheet will contain a header that labels the contents, date of last entry, person responsible for the data entry, as well a statement about the datum (WGS84/NAD83), Alaska state plane zone (4), and geoid (09) used to determine the orthometric heights (elevations) of the points.

All data will be entered into electronic format directly, either by importing the data directly from an ASCII file, or cutting and pasting directly from and to electronic files. No coordinate data will be hand entered (typed with a keyboard). This is to eliminate the possibility of erroneously transposing numbers. Once all data has been entered into the spreadsheet, the data fields will be cross-checked directly against the original GPS post-processing files to insure their accuracy.

Senior Review Study Staff: Steve Smith (Lead), Geovera

QC4 – Database Validation: Not applicable. There is no specific data deliverable associated with this protocol.

QC5 – Technical Review: Not applicable. There is no specific data deliverable associated with this protocol.

Field Data Backups

Both paper and electronic field forms should be backed up nightly in the field by scanning and downloading to a storage unit or photocopy to paper. Field notes books and electronic files are posted to the Study Internal Wiki sites where appropriate.

Data Revisions and Deliverables

The information provided above gives a general overview of the quality control process for RTK survey data. This data is typically associated with specific data sets (ie. miscellaneous ties, cross section water elevation, etc), and data revisions and deliverables are addressed further in those respective QC documents. There is no specific data deliverable for this protocol.

SUSITNA-WATANA HYDROELECTRIC PROJECT

AEA Susitna Project 2012 – Instream Task2 Cross-Section and Task5 Network Studies

GPS Survey Network –RTK Coordinates Miscellaneous Points

Last Update: 20130111

Last Update By: Steve Smith

Introduction

This document is intended to cover the quality control (QC) and final reporting for GPS RTK coordinates of miscellaneous data points tied into the project coordinate system during the course of the project. Accurate GPS coordinates are necessary for sustained, coordinated research, and will be submitted as a final deliverable.

Key Study staff for this data product:

- **Study Lead**: Steve Smith, Geovera, LLC
- **Field Survey Team Lead**: Billy Day, Geovera, LLC
- **Survey Data Processing**: Steve Smith, Geovera, LLC
- **Data Coordinator:** Michael Lilly, GW Scientific

There will be 5 levels of data QC, named QC1 to QC5. The first three levels are to be completed by the field study team, the fourth level by the Program Lead team, and the final level by senior professionals during analysis and reporting.

QC1 – Field Review: QC review performed by the person collecting field data, recorded in field books, and reviewed by the field team leader. The goal of QC1 is to identify errors and omissions and correct them under similar field conditions prior to leaving the field.

All data is reviewed for completeness, legibility, and logic. This is typically completed in the field at time of survey; however, if outstanding conditions related to field team safety require that the team depart the survey site prior to completing QC1, QC1 shall be completed immediately upon arriving at an appropriate location.

During the course of the project there is a requirement to tie miscellaneous data points into the project coordinate system. Field procedures and field book notations for the GPS RTK observations of miscellaneous data points shall be in accordance with the procedures outlined in the "GPS Survey Network—Control Point Survey QC Protocol" and "GPS Survey Network—RTK Survey QC Protocol."

Field book notations for GPS RTK base station occupation shall be in accordance with the Susitna-Watana Project Geodetic Control Standards. Notes for each RTK base station occupation will be checked to insure that the following information is included:

1. The beginning and ending times for the occupation.
2. The name of the surveyor performing the occupation.
3. The receiver identifier (make, model, serial number).
4. Antenna height measurements (in meters and feet).
5. The station identifier (name and/or survey point number).

Miscellaneous data points will be described in the field book. Descriptions will include at a minimum the RTK point number, description of the point tied, and any additional information that would further identify the object tied and/or its relevance to a specific study group. If necessary, a sketch will be included that will show the general layout of the point(s) tied, their relationship to the river, and any features that would help identify their location.

At the end of each day the electronic files will be downloaded from the GPS data collector put into a folder for that day's observations. The date of the observations shall be made a part of the folder name. The folders containing the electronic record of the cross section RTK and bathymetry data will be transferred to the main office for post-processing.

Field Staff: Steve Smith, Geovera, LLC

QC2- Data Processing: RTK data will be processed in conjunction with the senior review. See item QC3.

QC3 – Senior Review: Miscellaneous data point coordinates are reviewed by a senior professional on the project team, checking for logic, soundness, and adding qualifiers to results if warranted. Miscellaneous data points will be placed in a spreadsheet for final posting to the wiki. The spreadsheet will contain the point number, latitude and longitude (in decimal degrees), Alaska State Plane Zone 4 coordinates, the elevation of each point (in feet), and a descriptor that includes the point tied, and any pertinent information that will further identify the point. The spreadsheet will contain a header that labels the contents, date of last entry, person responsible for the data entry, as well a statement about the datum (WGS84/NAD83), Alaska state plane zone (4), and geoid (09) used to determine the orthometric heights (elevations) of the points.

All data will be entered into electronic format directly, either by importing the data directly from an ASCII file, or cutting and pasting directly from and to electronic files. No coordinate data will be hand entered (typed with a keyboard). This is to eliminate the possibility of erroneously transposing numbers. Once all data has been entered into the spreadsheet, the data fields will be cross-checked directly against the original GPS post-processing files to insure their accuracy.

Senior Review Study Staff: Steve Smith, Geovera, LLC

QC4 – Database Validation Electronic data files are submitted to the Program Lead's data resources manager. The deadline for this delivery is negotiated with the team Data Coordinator in consideration of the study due date.

Further QC4 verification of data isn't applicable to miscellaneous RTK tie data.

Data Coordinator: Michael Lilly, GW Scientific

QC5 – Technical Review: GPS coordinates corresponding to study cross sections are considered a historical record for the Project study. If GPS location errors are suspected by senior professionals when analyzing data, the Lead Surveyor or Study Lead if he is not available, must be notified to determine a course of corrective action. Data qualification may be applied by senior professionals when analyzing data for reports, trends, and FERC applications, however, the Study and Survey Leads must be notified if any substantive changes must be made to the data.

Field Data Backups

Both paper and electronic field forms should be backed up nightly in the field by scanning and downloading to a storage unit or photocopy to paper. Field notes books and electronic files are posted to the Study Internal Wiki sites where appropriate.

Data Revisions

Once the processed field data (QC3) has been submitted by the Study Lead (Michael Lilly) to AEA, and it has been validated as ready for incorporation into the Susitna project data collection (QC4), the data are considered to reside with AEA, and subsequent revisions will be made in a manner determined to be appropriate by the Program Lead team or AEA at the time. If a study team discovers that data require revisions, their Data Coordinator can send a formal, written request (i.e. email) to the Data Resources Manager.

Data Deliverables

The following information describes the final data deliverable for the Study miscellaneous RTK points. QC1 level data is taken from the Task 2 Wiki page. Once Level QC3 is complete, the updated document entitled "FA-IFS_XSection_RTK_Coordinate_Misc_Points_YYYYMMDD.xlsx" will be made available to other study teams on the Task 5 wiki site. Additionally, it will be made available to the Program Lead's data resources manager on a USB flash drive, with a transmittal memo.

The file will be submitted following the Project standards for data deliverables. The following subdirectory and file naming structures will be used.

Excel Files:

Subdirectory Descriptor	Format / Example
Project Name	SuWa (Level 1)
Submitting Consultant	GWS (Level 1)
Program Name	FA-IFS (Level 2)
Study Subject	XSection (Level 2)
Beginning Study Date	20120601 (Level 2)
Final Deliverable	RTK Coordinate Misc Points (Level 3)
Filename Descriptor	Format / Example
Program Name	FA-IFS
Study Subject	XSection
Data Type	RTK Coordinate Misc Points
Last Updated	YYYYMMDD (ex: 20120610)
File Type	.xlsx (excel file format)

Example:

SuWa_GWS\FA-IFS_XSection_20120601\ RTK_Coordinate_Misc_Points\ FA-IFS_XSection_RTK_Coordinate_Misc_Points_20130110.xlsx

Notes:

- DO NOT use spaces or special characters in subdirectory (folder) and file names
- File naming convention is to allow files to indicate content when stand alone and not in the submitted subdirectory

SUSITNA-WATANA HYDROELECTRIC PROJECT

AEA Susitna Project 2012 – Instream Task2 Cross-Section and Task5 Network Studies

GPS Survey Network – Cross-Section Baseline Control Points

Last Update: 20120109

Last Update By: Marielle Remillard

Introduction

This document is intended to cover the quality control (QC) and final reporting for GPS coordinates corresponding to Susitna River cross section baseline control. Accurate GPS coordinates are necessary for sustained, coordinated research, and will be submitted as a final deliverable.

Key Study staff for this data product:

- **Study Lead**: Steve Smith, Geovera, LLC
- **Field Survey Team Lead**: Billy Day, Geovera, LLC
- **Survey Data Processing**: Steve Smith, Geovera, LLC
- **Data Coordinator:** Michael Lilly, GW Scientific

There will be 5 levels of data QC, named QC1 to QC5. The first three levels are to be completed by the field study team, the fourth level by the Program Lead team, and the final level by senior professionals during analysis and reporting.

QC1 – Field Review: QC review performed by the person collecting field data, recorded in field books, and reviewed by the field team leader. The goal of QC1 is to identify errors and omissions and correct them under similar field conditions prior to leaving the field.

All data is reviewed for completeness, legibility, and logic. This is typically completed in the field at time of survey; however, if outstanding conditions related to field team safety require that the team depart the survey site prior to completing QC1, QC1 shall be completed immediately upon arriving at an appropriate location.

Each cross-section is monumented with a permanent set of survey monuments that control the cross-section baseline(s). Field procedures and field book notations for the monumentation of cross-section baseline points shall be in accordance with the procedures outlined in the "GPS

Survey Network—Control Point Survey QC Protocol" and "GPS Survey Network—RTK Survey QC Protocol."

Field book notations for GPS RTK base station occupation shall be in accordance with the Susitna-Watana Project Geodetic Control Standards. Notes for each RTK base station occupation will be checked to insure that the following information is included:

1. The beginning and ending times for the occupation.
2. The name of the surveyor performing the occupation.
3. The receiver identifier (make, model, serial number).
4. Antenna height measurements (in meters and feet).
5. The station identifier (name and/or survey point number).

Survey monuments (rebar w/ aluminum cap / brass tablet / spike etc.) set at cross-section baseline end points will be described in the field book. Descriptions will include at a minimum the RTK point number, monument description, the channel and bank (left or right), and the proximity to surrounding vegetation and geographical features. A sketch will be included that will show the general layout of the survey monuments set, their relationship to the river, and any features that would help identify their location.

At the end of each day the electronic files will be downloaded from the GPS data collector put into a folder for that day's observations. The date of the observations shall be made a part of the folder name. The folders containing the electronic record of the cross section RTK and bathymetry data will be transferred to the main office for post-processing.

Field Staff: Steve Smith, Geovera, LLC

QC2- Data Processing: RTK data will be processed in conjunction with the senior review. See item QC3.

QC3 – Senior Review: Cross-section coordinates are reviewed by a senior professional on the project team, checking for logic, soundness, and adding qualifiers to results if warranted. Cross-section baseline points will be placed in a spreadsheet for final posting to the wiki. Spreadsheets will be organized by project river mile, and the spreadsheet will contain the point number, latitude and longitude (in decimal degrees), Alaska State Plane Zone 4 coordinates, the elevation of each point (in feet), and a descriptor that includes the type of monument set, project river mile, and channel designation (LCL / MCL / RCR etc.). The spreadsheet will contain a header that labels the contents, date of last entry, person responsible for the data entry, as well a statement about the datum (WGS84/NAD83), Alaska state plane zone (4), and geoid (09) used to determine the orthometric heights (elevations) of the points.

All data will be entered into electronic format directly, either by importing the data directly from an ASCII file, or cutting and pasting directly from and to electronic files. No coordinate data will be hand entered (typed with a keyboard). This is to eliminate the possibility of erroneously transposing numbers. Once all data has been entered into the spreadsheet, the data fields will be cross-checked directly against the original GPS post-processing files to insure their accuracy.

Senior Review Study Staff: Steve Smith, Geovera, LLC

QC4 – Database Validation Electronic data files are submitted to the Program Lead's data resources manager. The deadline for this delivery is negotiated with the team Data Coordinator in consideration of the study due date.

Further QC4 verification of data isn't applicable to Cross Section Baseline Control data.

Data Coordinator: Michael Lilly, GW Scientific

QC5 – Technical Review: GPS coordinates corresponding to study cross sections are considered a historical record for the Project study. If GPS location errors are suspected by senior professionals when analyzing data, the Lead Surveyor or Study Lead if he is not available, must be notified to determine a course of corrective action. Data qualification may be applied by senior professionals when analyzing data for reports, trends, and FERC applications, however, the Study and Survey Leads must be notified if any substantive changes must be made to the data.

Field Data Backups

Both paper and electronic field forms should be backed up nightly in the field by scanning and downloading to a storage unit or photocopy to paper. Field notes books and electronic files are posted to the Study Internal Wiki sites where appropriate.

Data Revisions

Once the processed field data (QC3) has been submitted by the Study Lead (Michael Lilly) to AEA, and it has been validated as ready for incorporation into the Susitna project data collection (QC4), the data are considered to reside with AEA, and subsequent revisions will be made in a manner determined to be appropriate by the Program Lead team or AEA at the time. If a study team discovers that data require revisions, their Data Coordinator can send a formal, written request (i.e. email) to the Data Resources Manager.

Data Deliverables

The following information describes the final data deliverable for the Study cross-section baseline control. Once Level QC3 is complete, the updated document entitled “FA-IFS_XSection_X-Section_Baseline_Control_Points_YYYYMMDD” will be made available to other study teams on the Task 5 wiki site. Additionally, it will be made available to the Program Lead’s data resources manager on a USB flash drive, with a transmittal memo.

The file will be submitted following the Project standards for data deliverables. The following subdirectory and file naming structures will be used.

Excel Files:

Subdirectory Descriptor	Format / Example
Project Name	SuWa (Level 1)
Submitting Consultant	GWS (Level 1)
Program Name	FA-IFS (Level 2)
Study Subject	XSection (Level 2)
Beginning Study Date	20120601 (Level 2)
Final Deliverable	X-Section_Baseline_Control_Points (Level 3)
Filename Descriptor	Format / Example
Program Name	FA-IFS
Study Subject	XSection
Data Type	X-Section_Baseline_Control_Points
Last Updated	YYYYMMDD (ex: 20120610)
File Type	.xlsx (excel file format)

Example:
SuWa_GWS\FA-IFS_XSection_20120601\ X-Section_Baseline_Control_Points\ FA-IFS_XSection_X-Section_Baseline_Control_Points_20130107

Notes:

- DO NOT use spaces or special characters in subdirectory (folder) and file names
- File naming convention is to allow files to indicate content when stand alone and not in the submitted subdirectory

AEA Susitna Project 2012 – Instream Task2 Cross-Section and Task5 Network Studies

GPS Survey Network – Cross-Section Photos: Data QC Protocol

Last Update: 20130104

Last Update By: Marielle Remillard

Introduction

This document is intended to cover the data processing, quality control (QC), and final reporting for the cross section survey photographs (cross-section photos). The cross-section photos will be a final deliverable along with the final cross-section surveys, gaging data, and bathymetry data.

Key Study staff for this data product:

- **Study Lead**: Michael Lilly, GW Scientific
- **Field Survey Team Lead**: Billy Day (Lead), Ryan Taylor; Geovera
- **Photo Processing Staff**: Marielle Remillard (Lead), Martha Ballard; GW Scientific
- **Data Coordinator**: Joetta Zablotney, R2 Resource Consultants
- **Data Resource Manager:** Dana Stewart, R2 Resource Consultants

There will be 5 levels of data QC, named QC1 to QC5, each of which is tracked within the cross-section photo catalog (FA-IFS_XSection_X-Section_Survey_PhotoLog_YYYYMMDD). This allows for quick determination of the QC status of every cross-section photo data record. The first three levels are to be completed by the field study team, the fourth level by the Program Lead team, and the final level by senior professionals during analysis and reporting.

QC1 – Field Review: Includes QC review performed by the person collecting cross-section photo data and the subsequent review by the field team leader. The goal of QC1 is to save image files and back them up in an organized format prior to leaving the field. Review is done on 100% of cross-section photo data and includes accurate organization of the photos and all related information. This is typically completed in the end of the day for each survey event.

QC2 – Data Entry: Cross-section photo data is organized by river mile (RM) and renamed accordingly to the Project naming convention listed below. The goal of QC2 is to correctly rename the cross-section photos so they can later be used by Project studies to help locate cross-sections in the field and affirm river geometry and hydraulics.

Verification is performed on all cross-section photo data, including extrapolation of shorthand codes that might be used in the field into longhand or standard codes during cross-section photo renaming. Cross-section photo data naming errors are corrected at this time, then QC is recorded in the photo catalog column named “QC2,” containing the date and responsible staff as formatted as “YYYYMMDD FLastname” (example: “20120915 MRemillard”).

Data Entry Study Staff: Daniel Reichardt (Lead), Marielle Remillard, Martha Ballard; GW Scientific

QC3 – Senior Review: Cross-section photo data is reviewed by a senior professional on the project team, checking for logic, soundness, and adding qualifiers to results if warranted. Q3 is the step where the photo location (river mile) and orientation (left- vs. right-bank) are verified. This is the final review before submitting cross section photo data to the Program Lead, and is recorded in the photo catalog “QC3” column in the same format as QC2. This is also the QC level of raw files that have been “cleaned up” or otherwise processed for delivery to AEA.

Senior Review Study Staff: Billy Day (Lead), Geovera, or Michael Lilly, Daniel Reichardt; GW Scientific

QC4 – Database Validation: Electronic cross-section photo data files are submitted to and verified by the Program Lead’s data resources manager. The deadline for this delivery is negotiated with the team Data Coordinator in consideration of the study due date.

QC4 of photos will verify that file naming matches project standards and the task naming convention listed below. It will not verify photo contents against the file names or descriptive attributes within the catalog. QC4 of the photo catalog will be done as needed to incorporate it into a comprehensive photo catalog for the project. This involves verification of field name conventions, date formats, etc., splitting it into normalized tables as necessary and establishing primary and foreign keys. If any errors are detected, an error report is generated for the study team lead, who is expected to make corrections and resubmit data. The process is repeated until verification is clean and records are marked in the photo catalog column “QC4” (such as “20121001 DStewart”).

Program Lead’s Data Resource Manager: Dana Stewart, R2 Resource Consultants

QC5 – Technical Review: Photo content should not be altered during technical review. Qualification of photos or attributes within the catalog may be applied by senior professionals when analyzing data for reports, trends, and FERC applications. Some data items may be corrected or qualified within the database photo catalog itself, while others are only addressed in report text.

Notes pertaining to cross section photo data item are recorded in 2 columns: QC5 (date and staff) and QC5Edit (what is changed and why). This will serve as adequate documentation of the qualifications, so maintenance of additional documentation isn't usually necessary. QC5 revisions will be physically made by the Data Resource Manager, directed by the senior professional.

Field Data Backups

Field photos should be backed up nightly from cameras to field laptops and USB drives. The cross-section photos should then be placed by supporting field staff onto the Study Task2 internal wiki site for access by other study staff.

Data Revisions

Once the processed cross-section photo data (QC3) has been submitted by the Study Lead (Michael Lilly) to AEA via R2 (Joetta Zablotney), and it has been validated as ready for incorporation into the Susitna project database (QC4), the data is considered to reside with AEA, and subsequent revisions will only be made by the Program Lead team on their behalf. If a study team discovers that data requires revision, their Data Coordinator (Joetta Zablotney) can send a formal, written request (i.e. email) to the Data Resources Manager. Revisions will be made and the appropriate QC columns updated in the catalog, which will serve as adequate documentation.

Data Deliverables

The following information describes the intermediate and final data deliverable for the Study cross section photo data. QC1 information is primarily recorded in the field or field office when images are downloaded and organized. Cross-section photos are then stored on the Task 2 Wiki site for study staff access. The QC2 level files are saved on the Task2 Internal Wiki site until level QC3 is complete. Once Level QC3 is complete, the files will be made available to other study teams on the Task 5 wiki site. At this stage, the Excel photo index files and cross-section photo files will be made available to the Program Lead's data resources manager on a USB flash drive with transmittal memo.

The JPG files will be submitted following the Project standards for data deliverables. The following subdirectory and file naming structures will be used.

Subdirectory Descriptor	Format / Example / (Subdirectory level)
Project Name	SuWa (Level 1)
Submitting Consultant	GWS (Level 1)
Program Name	FA-IFS (Level 2)
Study Subject	XSection (Level 2)
Beginning Study Date	20120601 (Level 2)
Final Deliverable	Cross-Section Bank Photo Sets (Level 3)
Project River Mile	PRMxxx (ex: PRM75.0, PRM102.4) (Level 4)
Data Type	XSection_Survey_Photos (Level 4)
Filename Descriptor	Format / Example
Program Name	FA-IFS
Study Subject	XSection
Data Type	X-Section_Survey
QC Level	QC2 or QC3
Project River Mile	PRMxxx (ex: PRM75.0, PRM102.4)
Brailey River Mile	RMxxx (ex: RM113.0) (used only in 2012 studies)
Channel[1]	MC, LC, or RC (not applicable for all images)
Orientation[2]	L or R
Survey Date (Photo Date)	YYYYMMDD (ex: 20120610)
Original Photo Name	DC12345 (varies by camera and user)
File Type	.jpg (image file format)

Example:
SuWa_GWS\FA-IFS_XSection_20120601\ Cross-Section_Bank_Photo_Sets\PRM75.0_XSection_Survey_Photos\FA-IFS_XSection_X-Section_Survey_QC2_PRM179.8LCR_RM112.0LCR_20120610_DC12345.jpg

Notes:

- DO NOT use spaces or special characters in subdirectory (folder) and file names

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[1] Only relevant for cross sections where multiple channels were present. "MC" = main channel, "LC"= left-most channel when facing downstream, "RC"= right-most channel when facing downstream. If there are multiple middle channels, they will be numbered from left to right when facing downstream. Channel numbers only reflect the river on the date of observation. This naming convention will not be present where the river is a single channel.

[2] "R"= image faces downstream when the shore is on the right hand side and the river is on the left side of the image. The image faces upstream when the shore is on the left-hand side of the image and the river is on the right hand side. "L": the image faces downstream when the shore is on the left hand side of the image with the river on the right. The image faces upstream when the shore is on the right-hand side of the image and the river is on the left.

- File naming convention is to allow files to indicate content when stand alone and not in the submitted subdirectory
- Images are kept in their original resolution taken by the camera

SUSITNA-WATANA HYDROELECTRIC PROJECT

AEA Susitna Project 2012 – Instream Task2 Cross-Section and Task5 Network Studies

Level-Loop Vertical Elevation Surveys: Data QC Protocol

Last Update: 20120107

Last Update By: Marielle Remillard

Introduction

The F&A Program Lead team is tasked with implementing a standardized QA/QC protocol, intended for use in all environmental field studies in 2012, including fish and aquatic, water quality, river ice, terrestrial wildlife and botany, ISF, and others. This document will be presented to the leader and appointed Data Coordinator of each of these study teams.

Key Study staff for this data product:
- **Study Lead**: Michael Lilly, GW Scientific
- **Field Survey Team Lead**: Michael McCool, GWScientific
- **Data Processing Staff**: Steve Smith (Lead), Geovera; Marielle Remillard, GW Scientific
- **Data Coordinator**: Joetta Zablotney, R2 Resource Consultants
- **Data Resource Manager**: Dana Stewart, R2 Resource Consultants

QC Levels

There will be 5 levels of data QC, named QC1 to QC5, each of which is tracked within the electronic Elevation Survey Form (F-001). This allows for quick determination of the QC status of every data record. The first three levels are to be completed by the field study team, the fourth level by the Program Lead team, and the final level by senior professionals during analysis and reporting.

QC1 – Field Review: QC review performed by the person collecting field data, recorded in field books, and reviewed by the field team leader. The goal of QC1 is to identify errors and omissions and correct them under similar field conditions prior to leaving the field.

Review is done on 100% of data and includes completeness, legibility, level-loop closure, and logic on all information recorded. This is typically completed in the field at time of survey; however, if outstanding conditions related to field team safety require that the team depart the survey site prior to completing QC1, QC1 shall be completed immediately upon arriving at an appropriate location. Once completed, QC1 notations are made directly in the field book in an entry named “QC1”, containing the date and responsible staff and formatted as “YYYYMMDD FLastname” (example: “20120631 JDoe”).

QC2 – Data Entry: Data from paper forms are entered into an Excel electronic Elevation Survey Form (F-001), and data entry is verified by a second party against the field forms. The Excel field forms contain equations to help verify field calculations. It is important to note that the field team will sometimes complete a level survey using a temporary arbitrary datum. Commonly, the primary benchmark will be assigned an elevation of 100.00 ft for the purposes of completing the survey. When this approach is used, the data should first be entered into the electronic format using the same datum that was used during the field survey. Only after completing electronic entry and checking for accuracy and completeness is the arbitrary datum adjusted by using the previously established primary benchmark elevation. Draft entries will be made in the Water Surface Elevation Log (F-002). Adjustment of data from the arbitrary datum to the actual elevation will take place during QC3.

The goal of QC2 is to verify correct, complete, and consistent data entry. During QC2 previous surveys should be referenced to determine whether or not the elevation of benchmarks and monuments may have drifted. A note can be added to the electronic survey sheet regarding this movement. However, the elevation of the primary benchmark shall not be adjusted until QC3.

Verification is done on 100% of data entered and includes extrapolation of shorthand codes that might be used in the field into longhand or standard codes during data entry. Data entry errors are corrected at this time, then QC is recorded at the bottom of the Elevation Survey Form (F-001) in a column named “QC2”, containing the date and responsible staff and formatted as “YYYYMMDD FLastname” (example: “20120631 JDoe”).

Data Entry Study Staff: Daniel Reichardt (Lead), Marielle Remillard, Michael McCool, Kristie Hilton, GW Scientific

QC3 – Senior Review: Data is reviewed by a senior professional on the project team, checking for logic, soundness, and adding qualifiers to results if warranted. Data that was collected using an arbitrary 100 ft. elevation datum will be corrected at this time to reflect true elevation. A note will be made on the electronic survey form that the survey was completed with an arbitrary datum, which was adjusted during QC3. The Water Surface Elevation Log (F-002) will be updated at this stage. Calculated results can also be added at this time (formulas must be documented in the data dictionary). In addition, Q3 is the step where the elevation of the primary benchmark may be adjusted based upon all acquired evidence. If the primary benchmark elevation is adjusted a note to that affect must be added to the electronic survey form. This is the final review before submitting field data to the Program Lead, and is recorded in the “QC3” location of the Elevation Survey Form (F-001) in the same format as QC2. This is also the QC level of raw files that have been “cleaned up” or otherwise processed for delivery to AEA, such as photos and site diagrams.

Senior Review Study Staff: Steve Smith (Lead), Geovera, or Michael Lilly, GW Scientific, Daniel Reichardt, GW Scientific

QC4 – Database Validation: Electronic data files are submitted to the Program Lead’s data resources manager. The deadline for this delivery is negotiated with the team Data Coordinator in consideration of the study due date.

Further QC4 verification of data isn’t applicable to Level Loop Survey data.

Data Coordinator: Joetta Zablotney, R2 Resource Consultants

QC5 – Technical Review: Data revision and qualification may be applied by senior professionals when analyzing data for reports, trends, and FERC applications. Data calculations may be stored with the data. Some data items may get corrected or qualified within the database, while others are only addressed in report text. QC5 may be iterative, as data are analyzed in multiple years.

If a data item is revised directly, it’s recorded in 2 columns of the Level Loop Survey Log: QC5 (date and staff) and QC5Edit (what is revised and why). Additionally, the date and data coordinator should be updated in the file name when appropriate. This will serve as adequate documentation of the revisions, so maintenance of additional documentation isn’t usually necessary. QC5 revisions should not be made until reviewed and accepted by the Lead Surveyor or Study Lead if he is not available. The data will be changed in final Project files, and the Data Resource Manager notified.

Field Data Backups

Both paper and electronic field forms should be backed up nightly in the field by scanning and downloading to a storage unit or photocopy to paper. Field notes books and electronic files are posted to the Study Internal Wiki sites where appropriate.

Data Revisions

Once the processed field data (QC3) have been submitted by the Study Lead (Michael Lilly) to AEA via R2 (Joetta Zablotney), and it has been validated as ready for incorporation into the Susitna project data collection (QC4), the data are considered to reside with AEA, and subsequent revisions will be made in a manner determined to be appropriate by the Program Lead team or AEA at the time. If a study team discovers that data require revisions, their Data Coordinator can send a formal, written request (i.e. email) to the Data Resources Manager. Revisions will be made and the appropriate QC columns updated, which will serve as adequate documentation.

Data Deliverables

The following information describes the intermediate and final data deliverable for the Study level-loop elevation survey data. QC1 information is primarily recorded in the field and then field notebooks are scanned and stored on the Task 2 Wiki site. The QC2 level files are saved on the Task2 Internal Wiki site until level QC3 is complete. Once Level QC3 is complete, the files will be made available to other study teams on the Task 5 wiki site. At this stage, the Excel survey files and summary water level files will be made available to the Program Lead's data resources manager.

Data files will be submitted following the Project standards for data deliverables. The following subdirectory and file naming structures will be used.

Excel Files:

Subdirectory Descriptor	Format / Example
Project Name	SuWa (Level 1)
Submitting Consultant	GWS (Level 1)
Program Name	FA-IFS (Level 2)
Study Subject	XSection (Level 2)
Beginning Study Date	YYYYMMDD (Level 2)
Final Deliverable	LL_Surveys_at_Gaging_Stations (Level 3)
Gaging Station Name	ESSxx (Level 4)
Data Type	LL_Surveys (Level Loop) (Level 4)

Filename Descriptor	Format / Example
Program Name	FA-IFS
Study Subject	XSection
Data Type	LL_Surveys (Level Loop)
Form	F-001
QC Level	QC2 or QC3
Gaging Station Name	ESSxx
Survey Date	YYYYMMDD
File Type	.xlsx (most recent versions of Excel (2007 to 2013))

Example: SuWa_GWS\FA-IFS_XSection_20120601\ LL_Surveys_at_Gaging_Stations \ESS55_LL_Surveys\ FA-IFS _XSection_LL_Surveys_F-001_QC3_ESS10_20120731.xlsx

SUSITNA-WATANA HYDROELECTRIC PROJECT

AEA Susitna Project 2012 – Instream Task2 Cross-Section and Task5 Network Studies

Cross-Section Vegetation Descriptions: Data QC Protocol

Last Update: 20130117

Last Update By: Marielle Remillard

Introduction

This document covers the data processing, quality control (QC), and final reporting of the Susitna River cross-section vegetation descriptions. The cross-section vegetation descriptions will be a final deliverable.

Key Study staff for this data product:

- **Study Lead**: Michael Lilly, GW Scientific
- **Vegetation Description Lead**: Janet Kidd, ABR
- **Photo Processing Staff**: Michael Lilly, GW Scientific
- **Data Coordinator**: Joetta Zablotney, R2 Resource Consultants, Michael Lilly, GW Scientific

There will be 5 levels of data QC, named QC1 to QC5. The first three levels are to be completed by the field study team, the fourth level by the Program Lead team, and the final level by senior professionals during analysis and reporting.

QC1 – Field Review: Vegetation descriptions for riparian flora are based on photographs taken at each river cross-section. Cross-section photos are subject to five levels of QC review, as outlined in the "GPS Survey Network – Cross-Section Photos: Data QC Protocol" document. Photo quality control ensures extrapolation of short-hand field notes, organization of photos by Project River Mile (PRM), correct naming of photographs, and verification of photo dates and location.

QC2 – Data Entry: Riparian vegetation is identified at each cross-section based on cross section photographs. Vegetation descriptions, arranged by project river mile, are organized for use in Project related studies and reports. Vegetation descriptions, along with Project River Mile (PRM), photograph file name and date of image are recorded in the "Cross-Section Vegetation Description Index" (FA-IFS_XSection_Vegetation_Description_Index_YYYYMMDD).

Each river mile includes several photos and each photo was reviewed and assigned a vegetation class when appropriate (in some cases the photograph was of a survey marker or some other view not related to the channel banks). If more than one vegetation class was visible in a photo (typically due to increased terrace height/age), the vegetation type on the older terrace was used for the final designation. For example, the vegetation type directly adjacent to the channel may be a thin strip of open low willow, followed by a band of open tall alder willow, and then closed balsam poplar. In this case, Closed Balsam Poplar was the assigned vegetation class, even if the majority of the photos were of other vegetation types. In some cases the photograph was of the opposite bank. When applicable, we gave these photographs a vegetation class but the site class was determined using only photos of the designated channel view.

In several cases there was insufficient information to make a definitive decision on vegetation class or the confidence was low in the vegetation designation because the views available of vegetation were limited. These entries were either No Data or the level of confidence for the classification given was included in the notes field of the spreadsheet. In general, photo-documentation of riparian vegetation was limited and it is recommended that direct views of the bank vegetation be taken in addition to channel views. If the vegetation is represented primarily by forest, then the photograph should include as much of the canopy as possible.

Data Entry Study Staff: Rebecca Baird, ABR

QC3 – Senior Review: An accuracy assessment of the vegetation descriptions was conducted by Janet Kidd (ABR) and involved reviewing at least 25% of the final vegetation class assignments within each vegetation class for concurrence with the classification. All classes with only 1 occurrence were reviewed. This is the final review before submitting vegetation descriptions to the Program Lead.

Senior Review Study Staff: Janet Kidd (Lead), ABR

QC4 – Database Validation: The Cross-Section Vegetation Description Index is submitted to the Program Lead's data resources manager. The deadline for this delivery is negotiated with the team Data Coordinator in consideration of the study due date.

QC4 of the vegetation descriptions will verify that all necessary information is contained within the vegetation description index, and that naming matches project standards. It will not verify photo contents against the file names or descriptive attributes within the catalog.

QC5 – Technical Review: Vegetation information may be used by senior professionals when analyzing data for reports, trends, and FERC applications. If any errors are detected, the Project

Lead (Michael Lilly) and Lead Botanist (Janet Kidd) must be notified before changes are made to the Cross-Section Vegetation Description Index.

Data Revisions

Once the processed cross-section vegetation descriptions (QC3) have been submitted by the Study Lead (Michael Lilly) to AEA, and it has been validated as ready for incorporation into the Susitna project database (QC4), the data is considered to reside with AEA, and subsequent revisions will only be made by the Program Lead team on their behalf. If a study team discovers that data requires revision, their Data Coordinator (Joetta Zablotney) can send a formal, written request (i.e. email) to the Data Resources Manager.

Data Deliverables

The following information describes the intermediate and final data deliverable for the Study cross section photo data. QC1 information (cross-section photographs) is obtained from the Task 2 Internal Wiki site after they have completed the quality control review. The QC2 level vegetation descriptions are saved on the Task2 Internal Wiki site until level QC3 is complete. Once Level QC3 is complete, the files will be made available to other study teams on the Task 5 wiki site. At this stage, the Cross-Section Vegetation Description Index will be made available to the Program Lead's data resources manager on a USB flash drive with transmittal memo.

The excel files will be submitted following the Project standards for data deliverables. The following subdirectory and file naming structures will be used.

Excel Files:

Subdirectory Descriptor	Format / Example / (Subdirectory level)
Project Name	SuWa (Level 1)
Submitting Consultant	GWS (Level 1)
Program Name	FA-IFS (Level 2)
Study Subject	XSection (Level 2)
Beginning Study Date	20120601 (Level 2)
Final Deliverable	X-Section Vegetation Descriptions (Level 3)
Filename Descriptor	**Format / Example**
Program Name	FA-IFS
Study Subject	XSection
Data Type	Vegetation Description Index
QC Level	QC2 or QC3
Last Update Date	YYYYMMDD (ex: 20130117)
File Type	.xlsx (excel file format)

Example:

SuWa_GWS\FA-IFS_XSection_20120601\ X-Section_Vegetation_Descriptions \ FA-IFS_XSection_ Vegetation_Description_Index_20130117.xlsx

Notes:

- DO NOT use spaces or special characters in subdirectory (folder) and file names
- File naming convention is to allow files to indicate content when stand alone and not in the submitted subdirectory
- Images are kept in their original resolution taken by the camera

SUSITNA-WATANA HYDROELECTRIC PROJECT

AEA Susitna Project 2012 – Instream Task2 Cross-Section and Task5 Network Studies

Water-Surface Elevation Log QC Protocol

Last Update: 20130107

Last Update By: Marielle Remillard, GW Scientific

Introduction

This document covers data processing, quality control (QC), and final reporting for water level elevations measured at cross sections and gauging stations over time. GPS RTK (Real Time Kinematic) observations, level loop surveys, and tape down measurements are compiled into a water level elevation log for each location. The water level summary files will be submitted as a final deliverable.

Key Study staff for this data product:

- **Study Lead**: Michael Lilly (Lead), GW Scientific
- **Field Survey Team Lead**: Billy Day, Steve Smith, Geovera; Michael McCool, GW Scientific
- **Data Processing Staff**: Marielle Remillard, Martha Ballard; GW Scientific
- **Data Coordinator**: Michael Lilly, GW Scientific

QC Levels

There will be 5 levels of data QC, named QC1 to QC5. This allows for quick determination of the QC status of every data record. The first three levels are to be completed by the field study team, the fourth level by the Program Lead team, and the final level by senior professionals during analysis and reporting.

QC1 – Data Collection: Water elevation is measured using GPS RTK (Real Time Kinematic) observations, level loop surveys, and manual tape down readings. Each data set is prepared according to the respective QC document. QC Review includes checks for accuracy, logic, and completeness of data sets. When necessary, water elevation is converted to Project datum. Verified water elevation measurements are obtained from the internal Task 2 Wiki page.

QC2 – Data Processing: Water surface elevation results are compiled into the “Water Surface Elevation Log” (Form F-002) and organized by site location. There will be one summary file per gauging station or cross section. All data points are entered into the spreadsheet by copying and pasting from the master spreadsheets in order to reduce typing errors. All data is checked for correct, complete, and consistent data entry and processing.

The spreadsheet will contain the date and time of each observation, time unit (AST), method, manual WL reading, reference point, reference point elevation, estimated error, and water elevations. The spreadsheet will contain a header that labels the contents, date of last entry, person responsible for the data entry, as well a statement about the datum (WGS84/NAD83), Alaska state plane zone (4), and geoid (09) used to determine the orthometric heights (elevations) of the points. Channel designations (LCL, MCR, etc.), are provided for the water surface shots under the “remarks” heading if applicable.

Data Entry Study Staff: Marielle Remillard (Lead), Martha Ballard, GW Scientific

QC3 – Senior Review: After the water surface elevation logs have been compiled, an independent analysis of the data is done by a senior professional on the project team. River Mile descriptions are verified and each data point is cross-checked with the original data files including a check of the time-stamp, water elevation, and reference point (if applicable). Once the independent comparison of the data sets is complete, the spreadsheet is approved and posted to the Task 5 Wiki page for other agencies and partners to access.

Senior Review Study Staff: Michael Lilly (Lead), Marielle Remillard, GW Scientific

QC4 – Database Validation: Electronic data files are submitted to the Program Lead’s data resources manager. The deadline for this delivery is negotiated with the team Data Coordinator in consideration of the study due date.

Water level elevation logs will be update as new information is made available. The data coordinator will assist in ensuring the most current version is made available.

Data Coordinator: Michael Lilly, GW Scientific

QC5 – Technical Review: Data revision and qualification may be applied by senior professionals when analyzing data for reports, trends, and FERC applications. Data calculations may be stored with the data. Some data items may get corrected or qualified within the database, while others are only addressed in report text. QC5 may be iterative, as data are analyzed in multiple years.

Data Backups

Electronic field forms should be backed up to the Study Internal Wiki sites, in addition to external hard drives residing within AEA.

Data Revisions

Once the processed field data (QC3) have been submitted by the Study Lead (Michael Lilly) to AEA, and it has been validated as ready for incorporation into the Susitna project data collection (QC4), the data are considered to reside with AEA, and subsequent revisions will be made in a manner determined to be appropriate by the Program Lead team or AEA at the time. If a study team discovers that data require revisions, their Data Coordinator can send a formal, written request (i.e. email) to the Data Resources Manager.

Data Deliverables

The following information describes the intermediate and final data deliverable for the Study. QC1 information (verified RTK surveys, level loop surveys, and other manual readings) is obtained from the Task 2 Wiki site. QC2 summary logs are prepared as data is produced and stored on the Task 2 Wiki until level QC3 is complete. Once Level QC3 is complete, the files will be made available to other study teams on the Task 5 wiki site. At this stage, the Excel water-[surface] elevation summary files will be made available to the Program Lead's data resources manager.

Data files will be submitted following the Project standards for data deliverables. The following subdirectory and file naming structures will be used.

Excel Files:

Subdirectory Descriptor	Format / Example
Project Name	SuWa (Level 1)
Submitting Consultant	GWS (Level 1)
Program Name	FA-IFS (Level 2)
Study Subject	XSection (Level 2)
Beginning Study Date	20120601 (Level 2)
Final Deliverable	WS_Elevations (Level 3)
Location	Gauging Stations(Level 3)

Filename Descriptor	Format / Example
Program Name	FA-IFS
Study Subject	XSection
Data Type	WS Elevations
Form	F-002
Gauging Station	ESSxxx (if applicable)
Project River Mile	PRMxxx (ex: PRM75.0, PRM102.4)
Date Last Updated	YYYYMMDD
File Type	.xlsx (most recent versions of Excel (2007 to 2013))

Example: SuWa_GWS\FA-IFS_XSection_20120601\ WS_Elevations_Gauging_Stations\
FA-IFS_XSection _WS_Elevation_Log_F-002_ ESS10_PRM17.4_20130107.xlsx

Notes:

- DO NOT use spaces or special characters in subdirectory (folder) and file names
- File naming convention is to allow files to indicate content when stand alone and not in the submitted subdirectory.

SUSITNA-WATANA HYDROELECTRIC PROJECT

AEA Susitna Project 2012 – Instream Task2 Cross-Section and Task5 Network Studies

Continuous Stage Data QC Protocol

Last Update: 20130118

Last Update By: Dave Brailey, Brailey Hydrologic

Introduction

This document explains the data processing, quality control (QC), and final reporting of continuous stage data from AEA gaging stations. Uncorrected stage data is reported at 15-minute intervals via the Susitna-Watana Hydroelectric Data Network (Network). These data are converted to water surface elevations using the Aquarius Workstation software (v. 3.0).

Key Study staff for this data product:

- **Study Lead**: Dave Brailey (Lead), Brailey Hydrologic
- **Data Processing Staff**: Dave Brailey (Lead), Brailey Hydrologic
- **Senior Review Staff**: Michael Lilly (Lead), GW Scientific
- **Data Coordinator**: Joetta Zablotney, R2 Resource Consultants

QC Levels

There will be 5 levels of data QC, named QC1 to QC5. This allows for quick determination of the QC status of every data record. The first three levels are to be completed by the field study team, the fourth level by the Program Lead team, and the final level by senior professionals during analysis and reporting.

QC1 – Data Collection: Raw transducer data is downloaded from the Susitna-Watana Hydroelectric Data Network. Summaries of manual stage measurements are obtained from logs (form F-002) maintained on the internal project wiki site.

Data Entry Study Staff: Dave Brailey (Lead), Brailey Hydrologic

QC2 – Data Processing: Multiple transducer data files are combined into a single text file, and a file of manual stage measurements is prepared from logs maintained for each station (form F-002). These data are imported into the Aquarius Workstation software, which automatically identifies data gaps and removes duplicate records. The raw data are then converted to water surface elevations by matching manual stage measurements against the raw transducer data.

Post Processing Study Staff: Dave Brailey (Lead), Brailey Hydrologic

QC3 – Senior Review: The corrected stage data is reviewed by a senior professional on the project team, including comparison against nearby stations. After review and approval, the corrected stage data is posted to the Task 5 Wiki page for access by agencies and AEA partners.

Senior Review Study Staff: Michael Lilly, GW Scientific

QC4 – Database Validation: Electronic files of the corrected stage data will be submitted to the Program Lead's data resources manager. The deadline for this delivery is negotiated with the team Data Coordinator in consideration of the study due date.

Data Coordinator: Joetta Zablotney, R2 Resource Consultants; Michael Lilly, GW Scientific

QC5 – Technical Review: Data revision and qualification may be applied by senior professionals when analyzing data for reports, trends, and FERC applications. Data calculations may be stored with the data. Some data items may get corrected or qualified within the database, while others are only addressed in report text. QC5 may be iterative, as data are analyzed in multiple years.

Data Revisions

Once the processed field data (QC3) have been submitted by the Study Lead (Dave Brailey) to AEA via the Data Coordinator (Michael Lilly), and it has been validated as ready for incorporation into the Susitna project data collection (QC4), the data are considered to reside with AEA, and subsequent revisions will be made in a manner determined to be appropriate by the Program Lead team or AEA at the time. If a study team discovers that data require revisions, their Data Coordinator can send a formal, written request (i.e. email) to the Data Resources Manager. Revisions will be made as appropriate.

Data Deliverables

Data files will be submitted following the Project standards for data deliverables. The following subdirectory and file naming structures will be used.

Excel Files:

Subdirectory Descriptor	Format / Example
Project Name	SuWa (Level 1)
Submitting Consultant	GWS (Level 1)
Program Name	FA-IFS (Level 2)
Study Subject	XSection (Level 2)
Beginning Study Date	20120601 (Level 2)
Final Deliverable	Stage Hydrographs (Level 3)
Filename Descriptor	**Format / Example**
Program Name	FA-IFS
Study Subject	XSection
Data Type	Corrected Stage
QC Level	QC2 or QC3
Gauging Station	ESSxx (ex. ESS30)
Project River Mile	PRMxx.x (ex. PRM98.4)
Date Last Updated	YYYYMMDD
File Type	.xlsx (most recent versions of Excel (2007 to 2013))

Example: SuWa_GWS\FA-IFS_XSection_20120601\ Stage_Hydrographs \
FA-IFS_XSection_CorrectedStage_QC3_ESS30_PRM98.4_20130118.xlsx

Notes:

- DO NOT use spaces or special characters in subdirectory (folder) and file names
- File naming convention is to allow files to indicate content when stand alone and not in the submitted subdirectory.

AEA Susitna Project 2012 – Instream Task2 Cross-Section and Task5 Network Studies

Water-Surface Elevation Log QC Protocol

Last Update: 20130107

Last Update By: Marielle Remillard, GW Scientific

Introduction

This document covers data processing, quality control (QC), and final reporting for water level elevations measured at cross sections and gauging stations over time. GPS RTK (Real Time Kinematic) observations, level loop surveys, and tape down measurements are compiled into a water level elevation log for each location. The water level summary files will be submitted as a final deliverable.

Key Study staff for this data product:
- **Study Lead**: Michael Lilly (Lead), GW Scientific
- **Field Survey Team Lead**: Billy Day, Steve Smith, Geovera; Michael McCool, GW Scientific
- **Data Processing Staff**: Marielle Remillard, Martha Ballard; GW Scientific
- **Data Coordinator**: Michael Lilly, GW Scientific

QC Levels

There will be 5 levels of data QC, named QC1 to QC5. This allows for quick determination of the QC status of every data record. The first three levels are to be completed by the field study team, the fourth level by the Program Lead team, and the final level by senior professionals during analysis and reporting.

QC1 – Data Collection: Water elevation is measured using GPS RTK (Real Time Kinematic) observations, level loop surveys, and manual tape down readings. Each data set is prepared according to the respective QC document. QC Review includes checks for accuracy, logic, and completeness of data sets. When necessary, water elevation is converted to Project datum. Verified water elevation measurements are obtained from the internal Task 2 Wiki page.

QC2 – Data Processing: Water surface elevation results are compiled into the “Water Surface Elevation Log” (Form F-002) and organized by site location. There will be one summary file per gauging station or cross section. All data points are entered into the spreadsheet by copying and pasting from the master spreadsheets in order to reduce typing errors. All data is checked for correct, complete, and consistent data entry and processing.

The spreadsheet will contain the date and time of each observation, time unit (AST), method, manual WL reading, reference point, reference point elevation, estimated error, and water elevations. The spreadsheet will contain a header that labels the contents, date of last entry, person responsible for the data entry, as well a statement about the datum (WGS84/NAD83), Alaska state plane zone (4), and geoid (09) used to determine the orthometric heights (elevations) of the points. Channel designations (LCL, MCR, etc.), are provided for the water surface shots under the “remarks” heading if applicable.

Data Entry Study Staff: Marielle Remillard (Lead), Martha Ballard, GW Scientific

QC3 – Senior Review: After the water surface elevation logs have been compiled, an independent analysis of the data is done by a senior professional on the project team. River Mile descriptions are verified and each data point is cross-checked with the original data files including a check of the time-stamp, water elevation, and reference point (if applicable). Once the independent comparison of the data sets is complete, the spreadsheet is approved and posted to the Task 5 Wiki page for other agencies and partners to access.

Senior Review Study Staff: Michael Lilly (Lead), Marielle Remillard, GW Scientific

QC4 – Database Validation: Electronic data files are submitted to the Program Lead’s data resources manager. The deadline for this delivery is negotiated with the team Data Coordinator in consideration of the study due date.

Water level elevation logs will be update as new information is made available. The data coordinator will assist in ensuring the most current version is made available.

Data Coordinator: Michael Lilly, GW Scientific

QC5 – Technical Review: Data revision and qualification may be applied by senior professionals when analyzing data for reports, trends, and FERC applications. Data calculations may be stored with the data. Some data items may get corrected or qualified within the database, while others are only addressed in report text. QC5 may be iterative, as data are analyzed in multiple years.

Data Backups

Electronic field forms should be backed up to the Study Internal Wiki sites, in addition to external hard drives residing within AEA.

Data Revisions

Once the processed field data (QC3) have been submitted by the Study Lead (Michael Lilly) to AEA, and it has been validated as ready for incorporation into the Susitna project data collection (QC4), the data are considered to reside with AEA, and subsequent revisions will be made in a manner determined to be appropriate by the Program Lead team or AEA at the time. If a study team discovers that data require revisions, their Data Coordinator can send a formal, written request (i.e. email) to the Data Resources Manager.

Data Deliverables

The following information describes the intermediate and final data deliverable for the Study. QC1 information (verified RTK surveys, level loop surveys, and other manual readings) is obtained from the Task 2 Wiki site. QC2 summary logs are prepared as data is produced and stored on the Task 2 Wiki until level QC3 is complete. Once Level QC3 is complete, the files will be made available to other study teams on the Task 5 wiki site. At this stage, the Excel water-[surface] elevation summary files will be made available to the Program Lead's data resources manager.

Data files will be submitted following the Project standards for data deliverables. The following subdirectory and file naming structures will be used.

Excel Files:

Subdirectory Descriptor	Format / Example
Project Name	SuWa (Level 1)
Submitting Consultant	GWS (Level 1)
Program Name	FA-IFS (Level 2)
Study Subject	XSection (Level 2)
Beginning Study Date	20120601 (Level 2)
Final Deliverable	X-Section_WS_Elevation_and_Slope (Level 3)
Data	WS_Elevations (Level 4)
Filename Descriptor	**Format / Example**
Program Name	FA-IFS
Study Subject	XSection
Data Type	WS Elevations
Form	F-002
Gauging Station	ESSxxx (if applicable)
Project River Mile	PRMxxx (ex: PRM75.0, PRM102.4)
Date Last Updated	YYYYMMDD
File Type	.xlsx (most recent versions of Excel (2007 to 2013))

Example: SuWa_GWS\FA-IFS_XSection_20120601\ X-Section_WS_Elevation_and_Slope \WS_Elevations \FA-IFS_XSection _WS_Elevation_Log_F-002_PRM17.4_20130107.xlsx

Notes:

- DO NOT use spaces or special characters in subdirectory (folder) and file names
- File naming convention is to allow files to indicate content when stand alone and not in the submitted subdirectory.

SUSITNA-WATANA HYDROELECTRIC PROJECT

AEA Susitna Project 2012 – Instream Task2 Cross-Section and Task5 Network Studies

Cross-Section Water-Surface and Slope Observations QC Protocol

Last Update: 20130110

Last Update By: Marielle Remillard, GW Scientific

Introduction

The Susitna-Watana Hydroelectric Project Instream Flow Study Program requires measurement of water surface elevations at various stages of flow. As a part of the water flow study a series of cross-section measurements are taken at various locations along the river. Each cross-section is monumented with a permanent set of survey monuments that control the cross-section baseline(s). At various stages of flow, water surface measurements are taken at the cross-section locations with additional water surface measurements taken approximately 200 feet upstream and downstream of the cross-section locations.

Key Study staff for this data product:

- **Study Lead**: Steve Smith (Lead), Geovera, LLC
- **Field Survey Team Lead**: Billy Day, Geovera, LLC
- **Data Processing Staff**: Steve Smith (Lead), Geovera, LLC
- **Data Coordinator**: Joetta Zablotney, R2 Resource Consultants

QC Levels

There will be 5 levels of data QC, named QC1 to QC5. This allows for quick determination of the QC status of every data record. The first three levels are to be completed by the field study team, the fourth level by the Program Lead team, and the final level by senior professionals during analysis and reporting.

QC1 – Data Collection: Measurements are taken either with GPS RTK (Real Time Kinematic) observations or by running level loops from the RTK control points at each cross-section location. RTK and level loop data is processed according to the respective QC protocols. Review includes completeness, legibility, and accuracy of all information recorded.

QC2 – Data Processing: All data is verified for correct, complete, and consistent data entry and processing. After all RTK measurements are verified, the coordinates are exported to a spreadsheet and an ASCII file. A spreadsheet of the water surface measurement points is developed by copying and pasting from the master RTK coordinate spreadsheet. This insures that no coordinate data is transposed by typing error. River Mile designations are provided for the water surface shots by referencing the field book entries. The designators contain the cross-section river mile, the channel designation (LCL, MCR, etc.), and the distance upstream or downstream from the cross-section baseline if applicable. Slope calculations and distances between the baseline measurements and the upstream and downstream measurements are computed directly from the data controller by inversing between the points. The time-stamp information for each measurement is taken directly from the electronic data controller file.

Data Entry Study Staff: Billy Day, Geovera, LLC

QC3 – Senior Review: After the water surface measurement spreadsheets have been compiled, an independent analysis of the data is done by a senior professional on the project team. Coordinate data imported into the AutoCad drawing for each cross-section is compared to the spreadsheet data. River Mile descriptions are verified and independent calculations of the slopes and distances between the baseline measurement and the upstream and downstream measurements are performed. A check of the time-stamp in the electronic data file is done. Once the independent comparison of the data sets is complete, the spreadsheet is approved and posted to the Task 2 Wiki page for other agencies and partners to access.

The spreadsheet will contain the point number, date and time of the static observations, latitude and longitude (in decimal degrees), Alaska State Plane Zone 4 coordinates, elevation, point descriptor, river mile, and slope (where applicable) of each measurement. The spreadsheet will contain a header that labels the contents, date of last entry, person responsible for the data entry, as well a statement about the datum (WGS84/NAD83), Alaska state plane zone (4), and geoid (09) used to determine the orthometric heights (elevations) of the points.

Water surface observations are entered into the Water Elevation Log (Form F-002) at this time. There is one Water Elevation Log per cross section.

Senior Review Study Staff: Steve Smith (Lead), Geovera, LLC

QC4 – Database Validation: Electronic data files are submitted to the Program Lead’s data resources manager. The deadline for this delivery is negotiated with the team Data Coordinator in consideration of the study due date.

Further QC4 verification of data isn't applicable to water level and slope observations.

Data Coordinator: Joetta Zablotney, R2 Resource Consultants; Michael Lilly, GW Scientific

QC5 – Technical Review: Data revision and qualification may be applied by senior professionals when analyzing data for reports, trends, and FERC applications. Data calculations may be stored with the data. Some data items may get corrected or qualified within the database, while others are only addressed in report text. QC5 may be iterative, as data are analyzed in multiple years.

Additionally, the date and data coordinator should be updated in the file name when appropriate. This will serve as adequate documentation of the revisions, so maintenance of additional documentation isn't usually necessary. QC5 revisions should not be made until reviewed and accepted by the Lead Surveyor or Study Lead if he is not available. The data will be changed in final Project files, and the Data Resource Manager notified.

Field Data Backups

Both paper and electronic field forms should be backed up nightly in the field by scanning and downloading to a storage unit or photocopying to paper. Field notes books and electronic files are posted to the Study Internal Wiki sites where appropriate.

Data Revisions

Once the processed field data (QC3) have been submitted by the Study Lead (Michael Lilly) to AEA, and it has been validated as ready for incorporation into the Susitna project data collection (QC4), the data are considered to reside with AEA, and subsequent revisions will be made in a manner determined to be appropriate by the Program Lead team or AEA at the time. If a study team discovers that data require revisions, their Data Coordinator can send a formal, written request (i.e. email) to the Data Resources Manager.

Data Deliverables

The following information describes the intermediate and final data deliverable for the Study water surface elevation and slope calculation data. QC1 information consists of verified water level survey data, taken from the Task 2 wiki page. The QC2 processed summary files are saved on the Task2 Internal Wiki site until level QC3 is complete. Once Level QC3 is complete, the files will be made available to other study teams on the Task 5 wiki site. At this stage, the Excel survey data files will be made available to the Program Lead's data resources manager.

Data files will be submitted following the Project standards for data deliverables. The following subdirectory and file naming structures will be used.

Excel Files:

Subdirectory Descriptor	Format / Example
Project Name	SuWa (Level 1)
Submitting Consultant	GWS (Level 1)
Program Name	FA-IFS (Level 2)
Study Subject	XSection (Level 2)
Beginning Study Date	20120601 (Level 2)
Final Deliverable	X-Section_WS_Elevation_and_Slope (Level 3)
Data	Slope_Observations (Level 4)
Filename Descriptor	Format / Example
Program Name	FA-IFS
Study Subject	XSection
Data Type	X-Section WS and Slope
Data Collection Year	2012
Trip Number	TripX
Date Last Updated	YYYYMMDD
File Type	.xlsx (most recent versions of Excel (2007 to 2013))

Example: SuWa_GWS\FA-IFS_XSection_20120601\ X-Section_WS_Elevation_and_Slope \ Slope_Observations\ FA-IFS_XSection_X-Section_WS_and_Slope_2012_Trip1_20130110.xlsx

Notes:

- DO NOT use spaces or special characters in subdirectory (folder) and file names
- File naming convention is to allow files to indicate content when stand alone and not in the submitted subdirectory.

AEA Susitna Project 2012 – Instream Task2 Cross-Section and Task5 Network Studies

GPS Survey Network – Cross-Section Profile Coordinates

Last Update: 20130111

Last Update By: Marielle Remillard, GW Scientific

Introduction

This document covers the quality control (QC) and final reporting for GPS coordinates corresponding to Susitna River cross section control and profile points. Accurate GPS coordinates are necessary for sustained, coordinated research, and will be submitted as a final deliverable.

Key Study staff for this data product:

- **Study Lead**: Michael Lilly, GW Scientific
- **Field Survey Team Lead**: Dave Brailey, Brailey Hydrologic
- **Survey Data Processing**: Steve Smith, Geovera
- **GIS Processing and Data Coordinator:** Joetta Zablotney, R2 Resource Consultants

There will be 5 levels of data QC, named QC1 to QC5. The first three levels are to be completed by the field study team, the fourth level by the Program Lead team, and the final level by senior professionals during analysis and reporting.

QC1 – Field Review: QC review performed by the person collecting field data, recorded in field books, and reviewed by the field team leader. The goal of QC1 is to identify errors and omissions and correct them under similar field conditions prior to leaving the field.

All data is reviewed for completeness, legibility, and logic. This is typically completed in the field at time of survey; however, if outstanding conditions related to field team safety require that the team depart the survey site prior to completing QC1, QC1 shall be completed immediately upon arriving at an appropriate location.

Each cross-section is monumented with a permanent set of survey monuments that control the cross-section baseline(s). Field procedures and field book notations for the monumentation of cross-section end points shall be in accordance with the procedures outlined in the “GPS Survey

Network—Control Point Survey QC Protocol" and "GPS Survey Network—RTK Survey QC Protocol."

Cross section bathymetry measurements are obtained using Sontek M9 ADCP equipped with RTK GPS positioning. Multiple strings of bathymetry data are collected at each cross-section. These strings of data are collected as closely as possible to the cross-section baseline and run from shoreline to shoreline. Data collected on these runs include the geographic position (Latitude/Longitude) and the depth to the river bottom. The data is stored in the field in ASCII files that are transferred from the field computer and imported into spreadsheets.

Field book notations for Doppler bathymetry observations shall contain the name of the person making the observations, the date, and a brief description of the weather.

Concurrently with the collection of bathymetric data, the upland portion of the cross-section is surveyed using GPS RTK observations. Water surface measurements are taken at the cross-section baseline at the time of the bathymetric measurements. Those water surface elevations are used to convert the depth measurements from the bathymetric data to elevations conformed to the project control network.

At the end of each day the electronic will be downloaded from the GPS data collector and bathymetry field computer and put into a folder for that day's observations. The date of the observations shall be made a part of the folder name. The folders containing the electronic record of the cross section RTK and bathymetry data will be transferred to the main office for post-processing.

Preliminary Development of Bathymetry Data: Steve Smith, Geovera, LLC

QC2 – Data Entry: The geographic position and depth information from each run is extracted from the bathymetry spreadsheets, converted to Alaska Zone 4 state plane coordinates, and imported into an AutoCad drawing. A datum (the average water surface elevation from both sides of the channel) is applied to the depths resulting in xyz state plane coordinates conformed to the project control network. Bathymetric data points nearest to the cross-section baseline and the upland RTK points are then projected to the baseline and the resulting coordinates are exported to an ASCII file. The coordinate data is then imported from the ASCII file into a spreadsheet for final reporting. This insures that no coordinate data is transposed by typing error.

Processing Staff: Steve Smith, Geovera, LLC

QC3 – Senior Review: Cross-section coordinates are reviewed by a senior professional on the project team, checking for logic, soundness, and adding qualifiers to results if warranted. Cross-section end- and mid-points will be placed in a spreadsheet (FA-IFS_XSection_X-Section_Coordinates_QC3_PRMxx.x_YYYYMMDD) for final posting to the wiki. Spreadsheets will be organized by project river mile, and the spreadsheet will contain the point number, latitude and longitude (in decimal degrees), Alaska State Plane Zone 4 coordinates, and elevation of each point measured along the cross section. The spreadsheet will contain a header that labels the contents, date of last entry, person responsible for the data entry, as well a statement about the datum (WGS84/NAD83), Alaska state plane zone (4), and geoid (09) used to determine the orthometric heights (elevations) of the points.

All data will be entered into electronic format directly, either by importing the data directly from an ascii file, or cutting and pasting directly from and to electronic files. No coordinate data will be hand entered (typed with a keyboard). This is to eliminate the possibility of erroneously transposing numbers. Once all data has been entered into the spreadsheet, the data fields will be cross-checked directly against the original GPS post-processing files to insure their accuracy.

Senior Review Study Staff: Steve Smith, Geovera, LLC

QC4 – Database Validation: The final list of cross-section coordinates are submitted to the Program Lead's data resources manager, checked for completeness, and stored according to the project database schema. The deadline for this delivery is negotiated with the team Data Coordinator in consideration of the study due date.

Data Coordinator: Joetta Zablotney, R2 Resource Consultants; Michael Lilly, GW Scientific

QC5 – Technical Review: GPS coordinates corresponding to study cross sections are considered a historical record for the Project study. If GPS location errors are suspected by senior professionals when analyzing data, the Lead Surveyor or Study Lead if he is not available, must be notified to determine a course of corrective action.

Data revision and qualification may be applied by senior professionals when analyzing data for reports, trends, and FERC applications. QC5 may be iterative, as data are analyzed in multiple years.

Field Data Backups

Both paper and electronic field forms should be backed up nightly in the field by scanning and downloading to a storage unit or photocopy to paper. Field notes books and electronic files are posted to the Study Internal Wiki sites where appropriate.

Data Revisions

Once the processed field data (QC3) has been submitted by the Study Lead (Michael Lilly) to AEA, and it has been validated as ready for incorporation into the Susitna project data collection (QC4), the data are considered to reside with AEA, and subsequent revisions will be made in a manner determined to be appropriate by the Program Lead team or AEA at the time. If a study team discovers that data require revisions, their Data Coordinator can send a formal, written request (i.e. email) to the Data Resources Manager.

Data Deliverables

The following information describes the final data deliverable for the Study cross-section coordinates. Once Level QC3 is complete, the updated document entitled "FA-IFS_XSection_X-Section_Coordinates_QC3_PRMxx.x_YYYYMMDD" will be made available to other study teams on the Task 5 wiki site. Additionally, it will be made available to the Program Lead's data resources manager on a USB flash drive, with a transmittal memo.

The file will be submitted following the Project standards for data deliverables. The following subdirectory and file naming structures will be used.

Subdirectory Descriptor	Format / Example
Project Name	SuWa (Level 1)
Submitting Consultant	GWS (Level 1)
Program Name	FA-IFS (Level 2)
Study Subject	XSection (Level 2)
Beginning Study Date	20120601 (Level 2)
Final Deliverable	X-Section Profile Coordinates (Level 3)
Filename Descriptor	Format / Example
Program Name	FA-IFS
Study Subject	XSection
Data Type	X-Section_Coordinates
QC Level	QC2 or QC3
Project River Mile	PRMxxx (ex: PRM75.0, PRM102.4)
Last Updated	YYYYMMDD (ex: 20120610)
File Type	.xlsx (excel file format)

Example:
SuWa_GWS\FA-IFS_XSection_20120601\ X-Section_Profile_Coordinates \ FA-IFS_XSection_X-Section_Coordinates_QC3_PRM80.0_20130110.xlsx

Notes:

- DO NOT use spaces or special characters in subdirectory (folder) and file names
- File naming convention is to allow files to indicate content when stand alone and not in the submitted subdirectory

SUSITNA-WATANA HYDROELECTRIC PROJECT

AEA Susitna Project 2012 – Instream Task2 Cross-Section and Task5 Network Studies

ADCP Cross-Section Discharge Measurement QC Protocol

Last Update: 20130108

Last Update By: Marielle Remillard, GW Scientific

Introduction

This document explains the data processing, quality control (QC), and final reporting of discharge measurements made using acoustic Doppler current profilers (ADCPs).

Key Study staff for this data product:

- **Study Lead**: Dave Brailey (Lead), Brailey Hydrologic
- **Field Survey Team Lead**: Dave Brailey (Lead), Brailey Hydrologic; Billy Day, Geovera
- **Data Processing Staff**: Dave Brailey (Lead), Brailey Hydrologic
- **Senior Review Staff**: Adinda Demske (Lead), HDR
- **Data Coordinator**: Joetta Zablotney, R2 Resource Consultants

QC Levels

There will be 5 levels of data QC, named QC1 to QC5. This allows for quick determination of the QC status of every data record. The first three levels are to be completed by the field study team, the fourth level by the Program Lead team, and the final level by senior professionals during analysis and reporting.

QC1 – Data Collection: Discharge measurements are recorded using an acoustic Doppler current profiler following current USGS guidance (Mueller and Wagner 2009; OSW 2012a). Data are recorded in the field logbook and in electronic files. Daily backups are maintained for the field logbooks and electronic files.

Data Entry Study Staff: Dave Brailey (Lead), Brailey Hydrologic

QC2 – Data Post Processing: Data are reprocessed to evaluate moving bed conditions, GPS and bottom-track quality, velocity profile extrapolation settings, and other criteria recommended by current USGS guidance (OSW 2012b). Preliminary ratings are developed in accordance with current USGS guidance (OSW 2012b).

Post Processing Study Staff: Dave Brailey (Lead), Brailey Hydrologic

QC3 – Senior Review: An independent analysis of the discharge data and preliminary ratings is done by a senior professional on a separate AEA study team. Results are summarized in a written narrative and proposed revisions are submitted to the Field Survey Team Lead (David Brailey). After review and approval of the revisions, a summary of final discharge data is posted to the Task 5 Wiki page for access by agencies and AEA partners.

Senior Review Study Staff: Adinda Demske (Lead), HDR

QC4 – Database Validation: Electronic data files are submitted to the Program Lead's data resources manager. The deadline for this delivery is negotiated with the team Data Coordinator in consideration of the study due date.

Data Coordinator: Joetta Zablotney, R2 Resource Consultants; Michael Lilly, GW Scientific

QC5 – Technical Review: Data revision and qualification may be applied by senior professionals when analyzing data for reports, trends, and FERC applications. Data calculations may be stored with the data. Some data items may get corrected or qualified within the database, while others are only addressed in report text. QC5 may be iterative, as data are analyzed in multiple years.

Data Revisions

Once the processed field data (QC3) have been submitted by the Study Lead (Dave Brailey) to AEA via the Data Coordinator (Michael Lilly), and it has been validated as ready for incorporation into the Susitna project data collection (QC4), the data are considered to reside with AEA, and subsequent revisions will be made in a manner determined to be appropriate by the Program Lead team or AEA at the time. If a study team discovers that data require revisions, their Data Coordinator can send a formal, written request (i.e. email) to the Data Resources Manager. Revisions will be made as appropriate.

Data Deliverables

Data files will be submitted following the Project standards for data deliverables. The following subdirectory and file naming structures will be used.

Excel Files:

Subdirectory Descriptor	Format / Example
Project Name	SuWa (Level 1)
Submitting Consultant	GWS (Level 1)
Program Name	FA-IFS (Level 2)
Study Subject	XSection (Level 2)
Beginning Study Date	20120601 (Level 2)
Final Deliverable	X-Section_Discharge_ Measurements (Level 3)
Filename Descriptor	Format / Example
Program Name	FA-IFS
Study Subject	XSection
Summary Year	2012
Data Type	ADCP X-Section Discharge Summary
Date Last Updated	YYYYMMDD
File Type	.xlsx (most recent versions of Excel (2007 to 2013))

Example: SuWa_GWS\FA-IFS_XSection_20120601\ X-Section_Discharge_ Measurements \
FA-IFS_XSection_ 2012_ADCP_X-Section_Discharge_Summary_20130105.xlsx

Notes:

- DO NOT use spaces or special characters in subdirectory (folder) and file names
- File naming convention is to allow files to indicate content when stand alone and not in the submitted subdirectory.

References Cited

Mueller, D.S. and Wagner, C.R. 2009. Measuring discharge with acoustic Doppler current profilers from a moving boat. U.S. Geological Survey Techniques and Methods 3A-22, 72 p.

U.S. Geological Survey, Office of Surface Water (OSW) 2012a. Processing ADCP discharge measurements on-site and performing ADCP check measurements. USGS OSW Technical Memorandum No. 2012-01, January 9, 2012.

________ 2012b. Review and rating of moving-boat ADCP Q measurements. USGS Hydroacoustics Webinar, October 4, 2012.

SUSITNA-WATANA HYDROELECTRIC PROJECT

AEA Susitna Project 2012 – Instream Task2 Cross-Section and Task5 Network Studies

Rating Curve Development QC Protocol

Last Update: 20130119

Last Update By: Marielle Remillard, GW Scientific

Introduction

This document explains the data processing, quality control (QC), and final reporting of cross-section rating curves. Rating curves express the relationship between stage and discharge at a given location on a stream. Depending on the complexity of the relationship, six to ten stage-discharge measurements are required for initial rating curve development, and additional measurements are required if flow conditions are altered (by floods, for example). Because a maximum of three stage-discharge measurements were obtained at each cross section during 2012, insufficient data is available to develop rating curves. However, the 2012 stage-discharge data will be plotted to support hydraulic modeling efforts, and to guide future data collection activities.

Key Study staff for this data product:
- **Study Lead**: Dave Brailey (Lead), Brailey Hydrologic
- **Data Processing Staff**: Dave Brailey (Lead), Brailey Hydrologic
- **Senior Review Staff**: Michael Lilly (Lead), GW Scientific
- **Data Coordinator**: Joetta Zablotney, R2 Resource Consultants; Michael Lilly, GW Scientific

QC Levels

There will be 5 levels of data QC, named QC1 to QC5. This allows for quick determination of the QC status of every data record. The first three levels are to be completed by the field study team, the fourth level by the Program Lead team, and the final level by senior professionals during analysis and reporting.

QC1 – Data Collection: Rating curves are developed from concurrent stage and discharge measurements. Stage and discharge data will be measured and verified according to their respective QC protocols. Data already verified for completeness and accuracy will be obtained from the internal Task 2 Wiki site.

Data Entry Study Staff: Dave Brailey (Lead), Brailey Hydrologic

QC2 – Data Processing: Stage and discharge data will be imported into the Rating Development Toolbox of the Aquarius Workstation software (v 3.0), and a preliminary gage offset will be selected using the thalweg elevation as a guide. The rating points will then be plotted in both linear and log-log space, using the preliminary gage offset to linearize the log-log plots.

Post Processing Study Staff: Dave Brailey (Lead), Brailey Hydrologic

QC3 – Senior Review: The rating curve development plots (rating points) will be reviewed by a senior professional on the project team. The stage and discharge data will be inspected for accuracy and selection of an appropriate preliminary gage offset. After review and approval, the rating curve development plots will be posted to the Task 5 Wiki page for access by agencies and AEA partners.

Senior Review Study Staff: Michael Lilly, GW Scientific

QC4 – Database Validation: Electronic files of the rating curve development plots (rating points) will be submitted to the Program Lead's data resources manager. The deadline for this delivery is negotiated with the team Data Coordinator in consideration of the study due date.

Data Coordinator: Joetta Zablotney, R2 Resource Consultants; Michael Lilly, GW Scientific

QC5 – Technical Review: Data revision and qualification may be applied by senior professionals when analyzing data for reports, trends, and FERC applications. Data calculations may be stored with the data. Some data items may get corrected or qualified within the database, while others are only addressed in report text. QC5 may be iterative, as data are analyzed in multiple years.

Data Revisions

Once the processed field data (QC3) have been submitted by the Study Lead (Dave Brailey) to AEA via the Data Coordinator (Michael Lilly), and it has been validated as ready for incorporation into the Susitna project data collection (QC4), the data are considered to reside with AEA, and subsequent revisions will be made in a manner determined to be appropriate by the Program Lead team or AEA at the time. If a study team discovers that data require revisions, their Data Coordinator can send a formal, written request (i.e. email) to the Data Resources Manager. Revisions will be made as appropriate.

Data Deliverables

Data files will be submitted following the Project standards for data deliverables. The following subdirectory and file naming structures will be used. Please note: the location or cross-section river mile is not printed on the image itself, but is specified in the file name.

Image Files:

Subdirectory Descriptor	Format / Example
Project Name	SuWa (Level 1)
Submitting Consultant	GWS (Level 1)
Program Name	FA-IFS (Level 2)
Study Subject	XSection (Level 2)
Beginning Study Date	20120601 (Level 2)
Final Deliverable	Rating Curve Development Data (Level 3)
Filename Descriptor	**Format / Example**
Program Name	FA-IFS
Study Subject	XSection
Data Type	Rating Points
QC Level	QC2 or QC3
Project River Mile	PRMxx.x
Date Last Updated	YYYYMMDD
File Type	.jpg

Example: SuWa_GWS\FA-IFS_XSection_20120601\ Rating_Curve_Development_Data \
FA-IFS_XSection_RatingPoints_QC3_PRM98.4_20130118.jpg

Notes:

- DO NOT use spaces or special characters in subdirectory (folder) and file names
- File naming convention is to allow files to indicate content when stand alone and not in the submitted subdirectory.

SUSITNA-WATANA HYDROELECTRIC PROJECT

AEA Susitna Project 2012 – Instream Task2 Cross-Section and Task5 Network Studies

Surface Water Station Data Sets – Air Temperature Data: Data QC Protocol

Last Update: 20130122

Last Update By: Marielle Remillard

Introduction

This document is intended to cover the data processing, quality control (QC), and final reporting for the gauging station air temperature data. The data will be a final deliverable.

Key Study staff for this data product:

- **Study Lead**: Michael Lilly, GW Scientific
- **Data Processing Staff**: Ron Paetzold (Lead), Jamie Kretz, Demi Mixon; GW Scientific
- **Data Coordinator**: Joetta Zablotney, R2 Resource Consultants

There will be 5 levels of data QC, named QC1 to QC5, each of which is tracked within the Monthly Quality Reporting Summary for Surface Water Stations. This allows for quick determination of the QC status of every station data record. The first three levels are to be completed by the field study team, the fourth level by the Program Lead team, and the final level by senior professionals during analysis and reporting.

QC1 – Field Collection: Automated. Data are automatically downloaded from each station to the LoggerNet server.

QC2 – Data Entry: QC review performed by the person retrieving air temperature data from the LoggerNet server, and then by the field team leader. Air temperature data are organized by location and renamed accordingly to the Project naming convention listed below. The goal of QC2 is to identify missing and out-of-range data.

Data are retrieved from the LoggerNet server and imported into two Excel files: Original Data and QA Process Data. The Original Data files are saved without modification, except for addition of blank rows for missing data and deletion of duplicated data. The QA Process data files may be edited to remove obviously problematic data such as spikes. The data are imported from the Original Data files into monthly QA Calculation (sometimes called QA

Command) files where automatic checking for out-of-range data takes place. The QA Calculation files also check for completeness of data (missing or duplicated data). Notes are made on each monthly QA Calculation file about data problems. The results of all monthly QA Calculation files for all stations are summarized on the Monthly Quality Reporting Summary file (Excel).

Data are plotted using Origin graphing software in order to identify problems not detected by the automated Monthly QA Calculation files. These problems include things such as sensor drift, spikes in the data, etc. Problems discovered in the graphing process are noted on the QA Process data file and if appropriate, corrections are made to the data. The QA Process data will become the Archive Data after correction.

All QA files are posted to the Task 5 Wiki (http://network.susitna-watershed.net/). The QA Process data files are always in draft status and subject to change at any time.

Data QA Processing Staff: Ron Paetzold (Lead), Jamie Kretz, and Demi Mixon, GW Scientific

QC3 – Senior Review: Air temperature data are reviewed by a senior professional on the project team, checking for logic, soundness, and adding qualifiers to results if warranted. Q3 is the step where the QA Process Data file is finalized and saved as Archive Data. This is the final review before submitting data to the Program Lead. This is also the QC level of files that have been processed for delivery to AEA.

Senior Review Study Staff: Michael Lilly (Lead), Ron Paetzold, GW Scientific

QC4 – Database Validation: Electronic data files are posted to the Task 5 Wiki (http://network.susitna-watershed.net/) by the Program Lead's data resources manager. The deadline for this delivery is negotiated with the team Data Coordinator in consideration of the study due date.

Program Lead's Data Resource Manager: Joetta Zablotney, R2 Resource Consultants

QC5 – Technical Review: Air temperature data should not be altered during technical review. Qualification of air temperature or may be applied by senior professionals when analyzing data for reports, trends, and FERC applications.

Data Revisions

Once the processed air temperature data have been submitted by the Study Lead (Michael Lilly) to AEA via R2 (Joetta Zablotney), and it has been validated as ready for incorporation into the

Susitna project database (QC4), the data are considered to reside with AEA, and subsequent revisions will only be made by the Program Lead team on their behalf. If a study team discovers that data require revisions, their Data Coordinator (Joetta Zablotney) can send a formal, written request (i.e. email) to the Data Resources Manager.

Data Deliverables

The following information describes the intermediate and final data deliverable for the Study air temperature data. QC1 information (raw data) is automatically downloaded from each station to the LoggerNet server. The QC2 level files are saved on the Task5 Internal Wiki site until level QC3 is complete. Once Level QC3 is complete, the files will be made available to other study teams on the Task 5 wiki site. At this stage, the air temperature data files will be made available to the Program Lead's data resources manager on a USB flash drive with transmittal memo.

Data files will be submitted following the Project standards for data deliverables. The following subdirectory and file naming structures will be used.

Excel Files:

Subdirectory Descriptor	Format / Example
Project name	SuWa (Level 1)
Submitting comp./agency	GWS (Level 1)
Program Name	FA-IFS (Level 2)
Study Subject	Network (Level 2)
Beginning Study Date	20120601 (Level 2)
Final Deliverable	Air Temperature Data (Level 3)
Filename Descriptor	**Format / Example**
Program Name	FA-IFS
Study Subject	Network
Data Processing	Original Data, QA Process Data, or AirT (for final archive data)
QC level	QC1, QC2 or QC3
Station Name	ESSxx
Date of Last Data Point	YYYYMMDD
File Type	.xlsx (most recent versions of Excel (2007 to 2013))

Example: SuWa_GWS\FA-IFS_XSection_20120601\ Air_Temperature_Data \
FA-IFS_Network_AirT_QC3_ESS55_20120930.xlsx

Other File Examples:
Original Data: FA-IFS_Network_OriginalData_QC1_ESS55_20130104.xlsx (*Date is the date of the last data point in the file.*)

QA Process Data: FA-IFS_Network_QAProcessData_QC2_ESS55_20130104.xlsx (*Date is the date of the last data point in the file*.)
QA Graphs: FA-IFS_Network_QAPlots_QC2_ESS55_20130104.opj (*Date is the date of the last data point in the file*.)
Archive Data: (*Date of last data point in the file*.) FA-IFS_Network_AirT_QC3_ESS55_20120930.xlsx
Monthly QA Calculation Sheets. (*First date is the year and month of the data in the file. Second date is the date of the last modification*.)
FA-IFS_Network_QACalculationSheet_QC2_ESS55_Dec_2012_20130107.xlsx
Monthly Quality Reporting Summary. *(One sheet for all stations. Date is the date of the last update.)*FA-IFS_ Network _MonthlyQASummary_20121113.xlsx

Notes:
- DO NOT use spaces or special characters in subdirectory (folder) and file names
- File naming convention is to allow files to indicate content when stand alone and not in the submitted subdirectory.

AEA Susitna Project 2012 – Instream Task2 Cross-Section and Task5 Network Studies

Surface Water Station Data Sets – Water Temperature Data: Data QC Protocol

Last Update: 20130123

Last Update By: Marielle Remillard

Introduction

This document is intended to cover the data processing, quality control (QC), and final reporting for the gauging station water temperature data. The data will be a final deliverable.

Key Study staff for this data product:

- **Study Lead**: Michael Lilly, GW Scientific
- **Data Processing Staff**: Ron Paetzold (Lead), Jamie Kretz, Demi Mixon; GW Scientific
- **Senior Review**: Michael Lilly, Ron Paetzold; GW Scientific
- **Data Coordinator**: Joetta Zablotney, R2 Resource Consultants

There will be 5 levels of data QC, named QC1 to QC5, each of which is tracked within the Monthly Quality Reporting Summary for Surface Water Stations. This allows for quick determination of the QC status of every station data record. The first three levels are to be completed by the field study team, the fourth level by the Program Lead team, and the final level by senior professionals during analysis and reporting.

QC1 – Field Collection: Automated. Data is automatically downloaded from each station to the LoggerNet server.

QC2 – Data Entry: QC review performed by the person retrieving water temperature data from the LoggerNet server. Water temperature data is organized by location and renamed accordingly to the Project naming convention listed below. The goal of QC2 is to identify missing and out-of-range data.

Data is retrieved from the LoggerNet server and imported into two Excel files: Original Data and QA Process Data. The Original Data files are saved without modification, except for addition of blank rows for missing data and deletion of duplicated data. The QA Process data files may be edited to remove obviously problematic data such as spikes. The data are imported from the

Original Data files into monthly QA Calculation (sometimes called QA Command) files where automatic checking for out-of-range data takes place. The QA Calculation files also check for completeness of data (missing or duplicated data). Notes are made on each monthly QA Calculation file about data problems. The results of all monthly QA Calculation files for all stations are summarized on the Monthly Quality Reporting Summary file (Excel).

Data are plotted using Origin graphing software in order to identify problems not detected by the automated Monthly QA Calculation files. These problems include things such as sensor drift, spikes in the data, etc. Problems discovered in the graphing process are noted on the QA Process data file and if appropriate, corrections are made to the data. The QA Process data will become the Archive Data after correction.

All QA files are posted to the Task 5 Wiki (http://network.susitna-watershed.net/). The QA Process data files are always in draft status and subject to change at any time.

Data QA Processing Staff: Ron Paetzold (Lead), Jamie Kretz, and Demi Mixon, GW Scientific

QC3 – Senior Review: Water temperature data is reviewed by a senior professional on the project team, checking for logic, soundness, and adding qualifiers to results if warranted. Q3 is the step where the QA Process Data file is finalized and saved as Archive Data. This is the final review before submitting data to the Program Lead. This is also the QC level of files that have been processed for delivery to AEA.

Senior Review Study Staff: Michael Lilly (Lead), Ron Paetzold, GW Scientific

QC4 – Database Validation: Electronic data files are posted to the Task 5 Wiki (http://network.susitna-watershed.net/) by the Program Lead's data resources manager. The deadline for this delivery is negotiated with the team Data Coordinator in consideration of the study due date.

Program Lead's Data Resource Manager: Joetta Zablotney, R2 Resource Consultants

QC5 – Technical Review: Air temperature data should not be altered during technical review. Qualification of air temperature or may be applied by senior professionals when analyzing data for reports, trends, and FERC applications.

Data Revisions

Once the processed water temperature data has been submitted by the Study Lead (Michael Lilly) to AEA via R2 (Joetta Zablotney), and it has been validated as ready for incorporation into the Susitna project database (QC4), the data are considered to reside with AEA, and subsequent revisions will only be made by the Program Lead team on their behalf. If a study team discovers that data require revisions, their Data Coordinator (Joetta Zablotney) can send a formal, written request (i.e. email) to the Data Resources Manager.

Data Deliverables

The following information describes the intermediate and final data deliverable for the Study water temperature data. QC1 information (raw data) is automatically downloaded from each station to the LoggerNet server. The QC2 level files are saved on the Task5 Internal Wiki site until level QC3 is complete. Once Level QC3 is complete, the files will be made available to other study teams on the Task 5 wiki site. At this stage, the water temperature data files will be made available to the Program Lead's data resources manager on a USB flash drive with transmittal memo.

Data files will be submitted following the Project standards for data deliverables. The following subdirectory and file naming structures will be used.

Excel Files:

Subdirectory Descriptor	Format / Example
Project name	SuWa (Level 1)
Submitting comp./agency	GWS (Level 1)
Program Name	FA-IFS (Level 2)
Study Subject	Network (Level 2)
Beginning Study Date	20120601 (Level 2)
Final Deliverable	Water Temperature Data (Level 3)
Filename Descriptor	Format / Example
Program Name	FA-IFS
Study Subject	Network
Data Processing	Original Data, QA Process Data, or WaterT (for final archive data)
QC level	QC1, QC2 or QC3
Station Name	ESSxx
Date of Last Data Point	YYYYMMDD
File Type	.xlsx (most recent versions of Excel (2007 to 2013))

Example: SuWa_GWS\FA-IFS_XSection_20120601\ Water_Temperature_Data \
FA-IFS_Network_WaterT_QC3_ESS55_20120930.xlsx
Other File Examples:
Original Data: FA-IFS_Network_OriginalData_QC1_ESS55_20130104.xlsx (*Date is the date of the last data point in the file.*)

QA Process Data: FA-IFS_Network_QAProcessData_QC2_ESS55_20130104.xlsx (*Date is the date of the last data point in the file*.)
QA Graphs: FA-IFS_Network_QAPlots_QC2_ESS55_20130104.opj (*Date is the date of the last data point in the file*.)
Archive Data: (*Date of last data point in the file*.)
FA-IFS_Network_WaterT_QC3_ESS55_20120930.xlsx
Monthly QA Calculation Sheets. (*First date is the year and month of the data in the file. Second date is the date of the last modification*.)
FA-IFS_Network_QACalculationSheet_QC2_ESS55_Dec_2012_20130107.xlsx
Monthly Quality Reporting Summary. *(One sheet for all stations. Date is the date of the last update.)*FA-IFS_ Network _MonthlyQASummary_20121113.xlsx

Notes:

- DO NOT use spaces or special characters in subdirectory (folder) and file names
- File naming convention is to allow files to indicate content when stand alone and not in the submitted subdirectory.

SUSITNA-WATANA HYDROELECTRIC PROJECT

AEA Susitna Project 2012 – Instream Task2 Cross-Section and Task5 Network Studies

High and Low Resolution Station Images: Data QC Protocol

Last Update: 20130117

Last Update By: Marielle Remillard

Introduction

This document covers the data processing, quality control (QC), and final reporting of images taken by CC5MPX cameras installed at repeater and gauging stations. These camera images are a final deliverable, available in both high and low resolution formats.

Key Study staff for this data product:

- **Study Lead**: Michael Lilly, GW Scientific
- **Field Team Lead**: Mike McCool (Lead), Austin McHugh, James Shinas; GW Scientific
- **Photo Processing Staff**: Joshua Kugler, EEI; James Shinas, GW Scientific
- **Data Coordinator**: Joetta Zablotney, R2 Resource Consultants, Michael Lilly, GW Scientific

There will be 5 levels of data QC, named QC1 to QC5. QC1 is automated, QC2 and QC3 are to be completed by the field study team, QC4 is conducted by the Program Lead team, and QC5 by senior professionals during analysis and reporting.

QC1 – Field Review: The goal of QC1 is to save image files and back them up in an organized format. One high and one low resolution image is taken at each station every hour on the hour; images are saved to an SD card located within the camera. During site visits, all images are manually downloaded from the SD card to a laptop and stored in folders according to station ID.

Low-resolution (640x480) camera images are posted online (http://www.susitna-watershed.net/network.shtml) in real-time. The status of image data collected at each site will be monitored through the Susitna-Watana Hydroelectric Data Network Diagnostics page (http://www.susitna-watershed.net/stations/diag.html). If camera images posted online are not current, GWS staff are notified via email. Staff members attempt to troubleshoot the problems remotely first. If unsuccessful, the station will be visited by personnel. Gaps in the photo series must be corrected manually by downloading camera images from the station's camera and uploading them to the website in the correct time series.

QC2 – Data Entry: Images obtained during site visits will be sorted and renamed based on time signature via computer program. Low resolution images that were not posted on-line automatically will be added to the website to fill in data gaps. High resolution images will be posted to the web page alongside the corresponding low resolution image.

Dark (night-time) images are manually removed from the data set. Automatic website reporting of low-resolution images will be modified monthly to collect only daylight images while insuring no data is lost.

A title bar stamped on every image contains essential meta data information: date, time (AST), location, and site ID.

Data Entry Staff: Joshua Kugler, EEI; James Shinas, GW Scientific

QC3 – Senior Review: A random sample of images will be reviewed for quality, including camera focus and orientation. If any problems are detected, appropriate corrective measures will be taken by GW Scientific staff.

Senior Review Study Staff: Michael Lilly, Austin McHugh, Mike McCool; GW Scientific

QC4 – Database Validation: A complete set of camera image files, including both high and low resolution images, are submitted to the Program Lead's data resources manager for archival purposes. Images will be organized by site location and submitted via USB drive with submittal memo. The deadline for this delivery is negotiated with the team Study Lead or Data Coordinator in consideration of the study due date.

Study Lead: Michael Lilly, GW Scientific

QC5 – Technical Review: Photo content must not be altered during technical review. Qualification of photos or attributes may be applied by senior professionals when analyzing data for reports, trends, and FERC applications.

Data Revisions

Camera images from repeater, meteorological and/or gauging stations should not be modified in any way. Once the camera images have been posted online, the data is considered final and resides with AEA.

Data Deliverables

Camera images posted to the website (http://www.susitna-watershed.net/network.shtml) are considered final and available for Project study needs. Duplicate and high resolution copies of camera images are submitted via USB drive along with transmittal memo for historical records.

The JPG files will be submitted following the Project standards for data deliverables. The following subdirectory and file naming structures will be used.

Image File:

Subdirectory Descriptor	Format / Example / (Subdirectory level)
Project Name	SuWa (Level 1)
Submitting Consultant	GWS (Level 1)
Program Name	FA-IFS (Level 2)
Study Subject	XSection (Level 2)
Beginning Study Date	20120601 (Level 2)
Final Deliverable	Station Images (Level 3)
Station Name	ESSxx or ESRxx (ex: ESS55, ESR1) (Level 4)
Resolution	HighRes or LowRes (Level 5)
Filename Descriptor	Format / Example
Image Date and Time	YYYY-MM-DD-hh-mm (2013-01-06-13-45)
Resolution	HR (for high resolution images only)
File Type	.jpg (image file format)

Example:
SuWa_GWS\FA-IFS_XSection_20120601\ Station_Images \ESS55\HighRes\2013-01-06-13-45-HR.jpg

Notes:

- DO NOT use spaces or special characters in subdirectory (folder) and file names
- File naming convention is to allow files to indicate content when stand alone and not in the submitted subdirectory
- Images are kept in their original resolution taken by the camera

ATTACHMENT 2. STATION METADATA STANDARDS

ATTACHMENT 2. STATION METADATA STANDARDS

Susitna Hydrology Project
ESS40 Surface Water Station
Data Measurement and Recording Standards
Last Update: 06/24/2012
Last Update By: R Paetzold

Surface Water Station

Data-Collection Objectives: Meteorological data to evaluate the potential for hydro-electric power generation in the Susitna River region.
Time Recording Standard: **Always** Alaska Standard Time (UTC – 9).
Datalogger Scan Interval Standard: 60 seconds.
Time Measurement Standards:

- Hourly readings are recorded at the end of the hour; therefore, the hourly average water temperature, for example, with a 60-second scan interval and a time stamp of 14:00 is measured from 13:01 to 14:00:00. For a 60-second scan interval, the hourly average would be the average of 60 min = 60 values.
- Quarter-hourly readings are recorded every fifteen minutes starting at the top of the hour.
- Instantaneous readings are taken at the time specified by the time stamp.
- A day begins at midnight (00:00:00) and ends at midnight (23:59:55). All daily data are from the day prior to the date of the time stamp. For example, if the time stamp reads 09/09/2007 00:00 or 09/09/2007 12:00:00 AM, the data are from 09/08/2007.

Data Retrieval Interval: Data will be retrieved hourly.
Data Reporting Interval: Hourly

Images
Cameras: CC5MPXWD digital camera.
Memory Card: 8G Flash Memory Card
Flash Card Capacity: ~20,000 Images or over 2 years.
Images Taken: Triggered from external trigger (Logger control port. Allows images to be taken as needed.)
Images Saved on Datalogger: Five.
Image Trigger Interval: 60-minutes.
Data Retrieval Interval: One image every hour.
Connection: Direct for single camera

Air Temperature
Sensor: Triplicate YSI Series 44033 thermistors
Operating Range: -80°C to +75°C
Installation: In 6-gill radiation shield, non-aspirated.
Height: 2 meters
Output Units: kΩ, °C.
Scan Interval: 60 seconds

Output to Tables:

- Hourly Atmospheric Table:
  - Hourly Sample Air Temperature: Recorded at the top of each hour. (three values, one for each thermistor).
  - Hourly Average Air Temperature: Average of the 60 one-minute readings for the previous hour. (three values, one for each thermistor).
- Daily Table:
  - Daily Average Air Temperature: Average of all temperature readings for the previous day ending at midnight AST. (three values, one for each thermistor).
  - Daily Maximum Air Temperature: The highest reading from the previous day. (three values, one for each thermistor).
  - Daily Minimum Air Temperature: The lowest reading from the previous day. (three values, one for each thermistor).
- Hourly Raw Table:
  - Hourly Sample Sensor Resistance: Recorded at the top of each hour. "Raw" data in kΩ. (three values, one for each thermistor)
  - Hourly Average Sensor Resistance: Average of the 60 one-minute readings for the previous hour. "Raw" data in kΩ. (three values, one for each thermistor).

Water Height

Sensor: Two CS450 (Campbell Scientific, Inc) pressure transducer, SDI-12 type sensors
Pressure Measurement Range: 0-7.25 psig
Output Units: cm, ft (water height above sensor), psig
Scan Interval: 60 seconds
Output to Tables:

- Fifteen-Minute Water Height Table:
  - Fifteen-Minute Sample Water Height: Fifteen minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Average Water Height: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Maximum Water Height: Fifteen minute maximum of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Minimum Water Height: Fifteen minute minimum of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
- Daily Table:
  - Daily Average Water Height: Average of all readings for the previous day.
  - Daily Maximum Water Height: Maximum water height for the previous day.
  - Daily Minimum Water Height: Minimum water height for the previous day.

Surface-Water Temperature

Sensor: Two CS450 (Campbell Scientific, Inc) SDI-12 Sensors
Operating Range: -10°C to 80°C
Output Units: °C
Scan Interval: 60 seconds
Output to Tables:

- Fifteen-Minute Water Level Table:

  - Fifteen-Minute Average Water Temperature: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Maximum Water Temperature: The highest reading taken during the previous fifteen minutes.
  - Fifteen-Minute Minimum Water Temperature: The lowest reading taken during the previous fifteen minutes.
- Daily Table:
  - Daily Average Water Temperature: Average of all readings for the previous day.
  - Daily Maximum Water Temperature: the highest reading taken during the previous day.
  - Daily Minimum Water Temperature: the lowest reading taken during the previous day.

Surface-Water Temperature, Independent
Sensor: Five Model 109 (Campbell Scientific, Inc) Sensors
Operating Range: -50°C to 70°C
Output Units: °C
Scan Interval: 60 seconds
Output to Tables:
- Fifteen-Minute Water Level Table:
  - Fifteen-Minute Average Water Temperature: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Maximum Water Temperature: The highest reading taken during the previous fifteen minutes.
  - Fifteen-Minute Minimum Water Temperature: The lowest reading taken during the previous fifteen minutes.
- Daily Table:
  - Daily Average Water Temperature: Average of all readings for the previous day.
  - Daily Maximum Water Temperature: the highest reading taken during the previous day.
  - Daily Minimum Water Temperature: the lowest reading taken during the previous day.

Battery Voltage
Sensor: CH200
Output Units: V.
Scan Interval: 60 seconds
Output to Tables:
- Hourly Diagnostics Table:
  - Hourly Sample CR1000 Battery Voltage: Measured at the top of the hour.
  - Hourly Average CR1000 Battery Voltage: Average of the 60 one-minute readings for the previous hour.
  - Hourly Maximum CR1000 Battery Voltage: The highest reading from the previous hour.
  - Hourly Minimum CR1000 Battery Voltage: The lowest reading from the previous hour.

Battery Current
Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Sample CR1000 Battery Current: Measured at the top of the hour.
  - Hourly Average CR1000 Battery Current: Average of the 60 one-minute readings for the previous hour.
  - Hourly Maximum CR1000 Battery Current: The highest reading from the previous hour.
  - Hourly Minimum CR1000 Battery Current: The lowest reading from the previous hour.

Load Current
Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Sample Load Current: Measured at the top of the hour.
  - Hourly Average Load Current: Average of the 60 one-minute readings for the previous hour.
  - Hourly Maximum Load Current: The highest reading from the previous hour.
  - Hourly Minimum CR1000 Battery Current: The lowest reading from the previous hour.

Solar Panel Voltage
Sensor: CH200
Output Units: V.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Sample Solar Panel Voltage: Hourly reading at the top of the hour.
  - Hourly Average Solar Panel Voltage: Average of the 60 one-minute readings for the previous hour.
  - Hourly Maximum Solar Panel Voltage: The highest reading from the previous hour.
  - Hourly Minimum Solar Panel Voltage: The lowest reading from the previous hour.

Solar Panel Current
Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:

  - Hourly Sample Solar Panel Current: Hourly reading at the top of the hour.
  - Hourly Average Solar Panel Current: Average of the 60 one-minute readings for the previous hour.
  - Hourly Maximum Solar Panel Current: The highest reading from the previous hour.
  - Hourly Minimum Solar Panel Current: The lowest reading from the previous hour.

Datalogger (CR1000) Panel Temperature
Sensor: CR1000 Internal thermistor
Output Units: °C.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Average CR1000 Panel Temperature: Average of the 60 one-minute readings for the previous hour.

Voltage Regulator (CH200) Temperature
Sensor: CH200
Output Units: °C.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Average CR1000 Panel Temperature: Average of the 60 one-minute readings for the previous hour.

Resulting Final Storage Data Tables:
See Datalogger Output Files Excel Document

Notes
Definitions:
Scan interval = sampling duration = scan rate
Time of maximum or minimum values is not recorded
Sample reading = instantaneous reading
Beginning of the hour = top of the hour

Susitna ESS40 Surface Water Station Data Standards
Surface Water
Last Update: 6/24/12
Last Update By: R Paetzold

Key Analysis and Demonstration Questions
Determine the potential for generating hydroelectric power.

Data Files		Table
A	Station Diagnostics	HourlyDiag
B	Hourly table for all measurements	Hourly
C	15-min water table	QuarterHourlyWater
L	Hourly Raw Data (collected for field diagnostics)	HourlyRaw
M	Overall daily output	Daily

CSI Data Station Collection Standards Summary Table

			Data Tables									
			Quarter Hourly Data				Hourly Data				Daily	
Parameters	# Sensors	Units	Sample Point	Avg	Max	Min	Sample Point	Avg	Max	Min	Sample Point	Avg
- Air Temperature (YSI 44033)	3	°C					B	B				M
- Air Temperature (YSI 44033)	3	ohms					L	L				
- Water Ht (CS450)	2	cm, ft, psig	C	C	C	C						M
- Surface Water Temperature (CS450)	2	°C		C	C	C						M
- Surface Water Temperature (CSI 109)	5	°C		C	C	C						M
Monitoring System Diagnostic Conditions												
- Station ID	number	number	C				A,B, L				M	
- Battery Voltage	1	V					A	A	A	A		
- Battery Current	1	A					A	A	A	A		
- Load Current	1	A					A	A	A	A		
- Solar Panel Voltage	1	V					A	A	A	A		
- Solar Panel Current	1	A					A	A	A	A		
- CR1000 Temperature	1	°C						A				
- CH200 Voltage RegulatorTemperature	1	°C						A				
- Camera Images (every hour or on demand)	1											

ATTACHMENT 3. ADCP DISCHARGE MEASUREMENT SUMMARIES

Table A3-1. Combined Measurements.

Project River Mile	Brailey River Mile	Date	Time	Q, cfs	Rating	Gold Ck Q, cfs	Date	Time	Q, cfs	Rating	Gold Ck Q, cfs	Date	Time	Q, cfs	Rating	Gold Ck Q, cfs
PRM 225.0	RM 223.0	6/14/12	17:57	26,932	Good	42,600	8/9/12	15:03	11,260	Excellent	17,500	--	--	--	--	--
PRM 187.2	RM 184.1	6/17/12	16:30	27,698	Poor	32,800	8/6/12	16:13	14,707	Good	19,300	9/15/12	13:17	7,838	Good	10,800
PRM 186.2	RM 183.4	6/18/12	14:13	24,493	Good	32,200	8/6/12	17:05	14,419	Good	19,300	9/15/12	14:05	7,630	Excellent	10,800
PRM 185.5	RM 182.8	6/18/12	16:10	25,389	Good	32,300	--	--	--	--	--	--	--	--	--	--
PRM 185.2	RM 182.6	6/19/12	13:00	26,676	Good	34,400	--	--	--	--	--	--	--	--	--	--
PRM 184.9	RM 182.2	6/19/12	15:49	27,619	Good	35,500	8/6/12	18:24	14,239	Excellent	19,100	9/15/12	14:57	7,714	Excellent	11,000
PRM 184.4	RM 181.7	6/19/12	16:51	27,886	Fair	35,500	8/7/12	12:38	14,775	Good	18,300	9/15/12	15:52	8,353	Good	11,100
PRM 183.3	RM 180.3	6/20/12	13:19	29,426	Fair	36,300	8/7/12	13:35	14,183	Excellent	18,200	9/15/12	16:41	8,310	Excellent	11,300
PRM 182.9	RM 179.8	6/20/12	16:01	29,218	Good	36,400	--	--	--	--	--	--	--	--	--	--
PRM 181.6	RM 178.9	6/20/12	17:56	29,645	Excellent	36,200	8/7/12	14:44	14,705	Good	18,200	9/15/12	17:55	8,689	Good	11,500
PRM 179.5	RM 176.8	6/21/12	12:28	30,866	Fair	37,500	8/7/12	15:41	14,345	Excellent	18,100	9/14/12	17:05	8,361	Good	10,100
PRM 178.5	RM 176.1	6/16/12	18:35	29,756	Good	36,900	8/7/12	16:37	14,799	Excellent	18,000	9/14/12	17:47	8,738	Good	10,000
PRM 176.5	RM 173.9	6/21/12	14:40	31,240	Excellent	37,500	8/8/12	12:07	14,559	Excellent	17,300	9/16/12	14:50	10,768	Excellent	16,500
PRM 174.9	RM 172.0	6/21/12	16:12	31,163	Good	37,300	--	--	--	--	--	--	--	--	--	--
PRM 173.1	RM 170.0	6/21/12	17:39	30,571	Good	37,000	--	--	--	--	--	9/16/12	16:29	11,082	Excellent	17,200
PRM 170.1	RM 167.0	6/22/12	12:56	31,121	Good	36,700	8/8/12	15:16	14,568	Excellent	17,200	9/16/12	17:33	11,137	Excellent	17,600
PRM 168.1	RM 164.5	6/22/12	14:33	32,265	Good	36,700	8/8/12	16:03	14,655	Excellent	17,300	9/17/12	15:19	14,619	Good	20,200
PRM 153.7	RM 150.2	6/25/12	17:15	32,162	Good	35,900	8/10/12	15:03	14,588	Excellent	16,800	--	--	--	--	--
PRM 152.9	RM 149.5	6/26/12	13:43	30,487	Fair	35,800	--	--	--	--	--	--	--	--	--	--
PRM 152.1	RM 148.7	6/26/12	15:38	30,036	Good	36,000	8/10/12	16:07	15,351	Good	16,800	9/29/12	15:20	18,488	Good	20,000
PRM 151.1	RM 147.6	6/25/12	14:00	33,180	Good	36,400	--	--	--	--	--	--	--	--	--	--
PRM 148.3	RM 144.8	6/26/12	18:24	32,114	Good	35,600	8/10/12	18:03	14,941	Excellent	16,600	--	--	--	--	--
PRM 146.6	RM 143.2	6/27/12	12:24	31,030	Fair	34,400	--	--	--	--	--	--	--	--	--	--
PRM 145.7	RM 142.3	6/27/12	13:51	31,396	Fair	34,500	8/12/12	13:12	17,354	Excellent	18,100	9/29/12	16:51	18,131	Good	19,800
PRM 145.5	RM 142.1	6/27/12	14:40	31,868	Fair	34,800	--	--	--	--	--	--	--	--	--	--
PRM 144.9	RM 141.5	6/27/12	17:01	31,949	Fair	35,100	--	--	--	--	--	--	--	--	--	--
PRM 144.3	RM 140.8	6/27/12	18:50	31,121	Good	35,000	--	--	--	--	--	--	--	--	--	--
PRM 143.5	RM 140.2	6/28/12	12:17	30,330	Excellent	32,900	8/12/12	14:58	17,006	Excellent	18,100	--	--	--	--	--
PRM 143.0	RM 139.4	6/28/12	13:53	29,492	Good	32,900	--	--	--	--	--	--	--	--	--	--
PRM 142.2	RM 138.9	6/28/12	15:15	29,753	Good	33,200	8/12/12	16:29	16,798	Excellent	18,100	9/29/12	17:45	18,301	Excellent	19,800
PRM 141.9	RM 138.5	6/28/12	16:27	30,583	Good	33,200	8/12/12	17:13	16,803	Excellent	18,000	--	--	--	--	--
PRM 141.7	RM 138.2	6/28/12	17:41	30,555	Excellent	33,300	--	--	--	--	--	--	--	--	--	--
PRM 140.0	RM 136.7	6/29/12	14:48	30,378	Excellent	32,300	8/13/12	12:54	16,350	Excellent	17,800	9/30/12	13:56	17,619	Good	17,800
PRM 139.8	RM 136.4	6/29/12	16:21	30,378	Excellent	32,200	--	--	--	--	--	--	--	--	--	--
PRM 139.0	RM 135.7	6/30/12	13:56	28,039	Good	31,000	8/13/12	13:58	16,449	Good	17,700	--	--	--	--	--
PRM 138.7	RM 135.4	6/30/12	14:51	28,230	Excellent	31,000	8/13/12	14:48	16,344	Excellent	17,700	--	--	--	--	--
PRM 138.1	RM 134.7	6/30/12	16:33	28,203	Good	31,000	--	--	--	--	--	--	--	--	--	--
PRM 137.6	RM 134.3	6/30/12	18:13	27,893	Good	31,000	8/13/12	16:14	16,409	Excellent	17,600	9/30/12	15:00	17,382	Excellent	17,700
PRM 136.7	RM 133.3	7/1/12	13:35	26,756	Good	30,000	--	--	--	--	--	--	--	--	--	--
PRM 136.2	RM 132.9	7/1/12	16:06	26,943	Good	30,000	--	--	--	--	--	--	--	--	--	--
PRM 135.0	RM 131.8	7/1/12	18:33	26,526	Excellent	29,700	8/13/12	17:41	15,627	Excellent	17,400	--	--	--	--	--
PRM 134.3	RM 131.2	7/2/12	12:16	25,463	Good	28,000	--	--	--	--	--	10/1/12	13:40	15,568	Excellent	15,500
PRM 134.1	RM 130.9	7/2/12	13:18	26,166	Good	27,900	8/14/12	13:14	16,491	Excellent	17,400	--	--	--	--	--
PRM 133.8	RM 130.5	7/2/12	14:30	25,715	Good	28,000	8/14/12	14:05	16,275	Excellent	17,300	--	--	--	--	--
PRM 133.3	RM 130.0	7/2/12	16:22	25,678	Excellent	27,900	--	--	--	--	--	--	--	--	--	--
PRM 132.6	RM 129.4	7/2/12	17:57	25,046	Excellent	27,800	8/14/12	15:17	16,039	Good	17,300	--	--	--	--	--
PRM 131.4	RM 128.1	7/3/12	22:08	28,628	Good	31,200	--	--	--	--	--	--	--	--	--	--
PRM 129.7	RM 126.6	7/3/12	17:33	28,243	Good	30,900	8/14/12	17:00	16,330	Excellent	17,300	10/1/12	16:16	15,731	Excellent	15,400
PRM 128.1	RM 124.4	7/4/12	15:40	26,748	Good	30,000	8/15/12	12:50	15,926	Excellent	17,600	--	--	--	--	--
PRM 126.8	RM 123.3	7/4/12	17:22	27,608	Excellent	29,900	8/15/12	13:40	16,078	Excellent	17,600	10/1/12	17:02	15,582	Excellent	15,400
PRM 126.1	RM 122.6	7/5/12	14:24	27,248	Good	28,800	--	--	--	--	--	--	--	--	--	--
PRM 125.4	RM 121.8	7/5/12	16:38	26,427	Excellent	28,500	--	--	--	--	--	--	--	--	--	--
PRM 124.1	RM 120.7	7/5/12	18:11	26,132	Good	27,900	8/15/12	14:27	16,161	Excellent	17,600	10/1/12	17:42	15,582	Good	15,300
PRM 123.7	RM 120.3	7/6/12	12:18	23,875	Excellent	24,700	--	--	--	--	--	--	--	--	--	--
PRM 122.7	RM 119.3	7/6/12	14:23	23,331	Excellent	24,100	--	--	--	--	--	--	--	--	--	--
PRM 122.6	RM 119.2	7/6/12	15:59	22,890	Good	24,000	8/15/12	16:13	16,287	Excellent	17,600	--	--	--	--	--
PRM 120.7	RM 117.2	7/6/12	17:19	22,687	Good	23,400	--	--	--	--	--	--	--	--	--	--
PRM 119.9	RM 116.4	7/7/12	12:19	20,715	Excellent	21,600	8/16/12	12:54	16,005	Excellent	17,600	10/3/12	14:47	13,998	Excellent	13,500
PRM 118.4	RM 115.0	7/7/12	14:06	20,656	Excellent	21,600	--	--	--	--	--	--	--	--	--	--
PRM 117.4	RM 114.0	7/7/12	16:15	20,747	Excellent	21,100	--	--	--	--	--	--	--	--	--	--
PRM 116.6	RM 113.0	7/7/12	17:36	20,665	Excellent	21,000	8/16/12	14:15	16,136	Excellent	17,600	10/3/12	15:53	14,323	Excellent	13,400
PRM 116.3	RM 112.7	7/8/12	12:42	23,766	Excellent	28,600	--	--	--	--	--	--	--	--	--	--

Project River Mile	Brailey River Mile	Date	Time	Q, cfs	Rating	Gold Ck Q, cfs	Date	Time	Q, cfs	Rating	Gold Ck Q, cfs	Date	Time	Q, cfs	Rating	Gold Ck Q, cfs
PRM 115.7	RM 112.2	7/8/12	14:05	25,006	Excellent	28,900	--	--	--	--	--	--	--	--	--	--
PRM 115.4	RM 111.8	7/8/12	16:13	25,958	Excellent	29,100	--	--	--	--	--	--	--	--	--	--
PRM 114.4	RM 110.9	7/8/12	18:29	25,860	Excellent	29,100	--	--	--	--	--	--	--	--	--	--
PRM 113.6	RM 110.0	7/9/12	14:23	28,329	Excellent	31,900	8/16/12	16:38	16,311	Excellent	17,500	10/3/12	16:41	13,476	Excellent	13,400
PRM 111.9	RM 108.4	7/9/12	15:23	28,296	Good	31,900	--	--	--	--	--	--	--	--	--	--
PRM 110.5	RM 106.7	7/9/12	16:46	28,825	Good	31,800	8/17/12	14:57	15,254	Excellent	18,000	10/3/12	17:33	14,172	Excellent	13,400
PRM 108.3	RM 104.8	--	--	--	--	--	8/17/12	17:55	16,394	Good	17,900					
PRM 107.1	RM 103.0	7/9/12	18:26	28,409	Good	31,600	8/18/12	13:12	15,508	Excellent	16,300	10/4/12	14:10	14,558	Excellent	13,700
PRM 106.1	RM 102.4	--	--	--	--	--	8/18/12	14:22	15,278	Excellent	16,100	--	--	--	--	--
PRM 105.3	RM 101.5	--	--	--	--	--	8/18/12	15:52	15,362	Excellent	16,000	--	--	--	--	--
PRM 104.7	RM 101.0	--	--	--	--	--	8/18/12	17:48	15,377	Excellent	16,000	--	--	--	--	--
PRM 104.1	RM 100.4	--	--	--	--	--	8/19/12	12:49	15,345	Excellent	16,400	--	--	--	--	--
PRM 103.5	RM 99.6	--	--	--	--	--	--	--	--	--	--	10/4/12	16:49	14,575	Excellent	13,700
PRM 102.7	RM 98.8	7/10/12	13:53	26,635	Good	26,900	--	--	--	--	--	--	--	--	--	--
PRM 101.4	RM 98.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PRM 98.4	RM 95.0	7/11/12	14:09	46,499	Good	22,600	8/20/12	14:51	40,623	Good	16,600	10/5/12	14:37	39,065	Excellent	13,800
PRM 97.0	RM 94.0	7/11/12	18:27	45,118	Good	21,800	8/20/12	17:03	40,261	Excellent	17,400	--	--	--	--	--
PRM 91.6	RM 87.7						8/21/12	14:55	46,330	Excellent	18,500	--	--	--	--	--
PRM 91.0	RM 86.9	7/12/12	15:39	43,922	Good	20,100	8/21/12	16:51	46,197	Excellent	18,500	--	--	--	--	--
PRM 88.4	RM 84.6	--	--	--	--	--	8/22/12	15:01	41,697	Excellent	18,200	--	--	--	--	--
PRM 87.1	RM 83.0	7/12/12	18:00	42,550	Excellent	19,700	--	--	--	--	--	--	--	--	--	--
PRM 86.3	RM 82.0	7/13/12	13:13	41,895	Excellent	18,800	--	--	--	--	--	--	--	--	--	--
PRM 85.4	RM 81.2	--	--	--	--	--	8/22/12	18:01	40,468	Excellent	17,600	--	--	--	--	--
PRM 84.4	RM 80.0	--	--	--	--	--	8/23/12	15:16	36,988	Good	16,100	--	--	--	--	--
PRM 83.0	RM 79.0	7/13/12	16:09	41,975	Excellent	18,700	--	--	--	--	--	--	--	--	--	--
PRM 82.3	RM 78.0	--	--	--	--	--	8/23/12	17:52	37,947	Good	15,800	--	--	--	--	--
PRM 80.0	RM 76.0	--	--	--	--	--	8/24/12	15:07	36,580	Excellent	16,200	--	--	--	--	--

Notes:

1 No discharge measurements reported at PRM 101.4 (RM xx), insufficient data collected.

Table A3-2. Individual Measurements.

Date	Mid-point time	Site	Project River Mile	Brailey River Mile	ADCP Serial No.	Compass Calibration	Mmt duration, s	No. of Transects	% Top & Bottom Est's	Extrapolation Settings1	% Edge Est's.	Loop Test Results											
												Start time	Duration, s	DMG, ft	Velocity, ft/s		Direction, deg			% Corr	% bad	out-back
															Bed	Flow	Bed	Flow	Diff		BT	difference
6/11/12	8:25	15281000	--	Knik R.	3061	on-board	784	2	28.5	C/N-0.133	0.184	08:11	462	94.3	0.20	3.68	73.1	251.6	178.4	5.54	2.16	0.6
6/11/12	10:10	15281000	--	Knik R.	2837	on-board	904	2	28.3	C/N-0.115	0.173	09:56	544	103.7	0.19	3.61	81.5	253.3	171.9	5.28	2.95	0.2
6/14/12	17:57	15291500	225.0	223.0	3061	on-board	700	2	22.7	C/N-0.296	1.365	No loop test due to diving of ADCP in standing waves										
6/16/12	18:35	X176.1C1	178.5	176.1	3061	on-board	1884	6	23.0	C/N-0.218	0.093	No loop test due to diving of ADCP in standing waves										
6/17/12	16:30	X184.1C1	187.2	184.1	3061	on-board	1680	6	24.3	P/P-0.170	0.035	No loop test due to diving of ADCP in standing waves										
6/18/12	14:13	X183.4C1	186.2	183.4	3061	on-board	880	4	22.5	C/N-0.241	0.045	13:55	308	35.8	0.12	7.17	74.8	267.8	193.1	1.62	11.73	2.5
6/18/12	16:10	X182.8C1	185.5	182.8	3061	on-board	1012	4	25.2	C/N-0.213	0.063	15:54	312	80.1	0.26	6.83	73.9	268.7	194.8	3.76	4.18	6.3
6/19/12	12:04	X182.6C3	185.2	182.6	3061	on-board	700	4	27.6	C/N-0.160	0.261	11:56	194	~~17.4~~	~~0.09~~	6.60	~~57.2~~	283.1	~~225.9~~	~~1.36~~	25.77	2.9
6/19/12	13:02	X182.6C1	185.2	182.6	3061	on-board	592	4	35.8	C/N-0.240	1.795	12:53	155	~~6.7~~	~~0.04~~	3.63	~~16.2~~	298.8	~~283.6~~	~~1.19~~	14.29	2.8
6/19/12	13:54	X182.6C2	185.2	182.6	3061	on-board	812	4	27.9	C/N-0.151	0.241	13:40	307	~~86.7~~	~~0.28~~	8.41	~~11.9~~	275.5	~~263.6~~	~~3.36~~	44.44	4.9
6/19/12	15:49	X182.2C1	184.9	182.2	3061	on-board	872	4	24.4	C/N-0.215	0.044	15:02	317	59.0	0.19	7.57	110.5	262.5	152.0	2.46	30.70	17.3
6/19/12	16:51	X181.7C1	184.4	181.7	3061	on-board	948	4	23.8	C/N-0.202	0.196	16:30	262	99.6	0.38	8.19	126.2	281.2	155.0	4.64	16.48	16.5
6/20/12	13:19	X180.3C1	183.3	180.3	3061	on-board	908	4	22.6	C/N-0.218	0.021	13:08	252	~~32.6~~	~~0.13~~	7.81	~~227.9~~	253.2	~~25.4~~	~~1.66~~	8.76	10.8
6/20/12	15:03	X179.8C1	182.9	179.8	3061	on-board	636	4	30.1	C/N-0.204	1.577	14:41	187	~~19.2~~	~~0.10~~	8.16	~~263.1~~	244.4	~~341.3~~	~~1.26~~	11.29	2.4
6/20/12	16:58	X179.8C2	182.9	179.8	3061	on-board	852	4	23.4	C/N-0.229	0.104	16:46	268	25.0	0.09	8.36	104.5	274.6	170.2	1.12	9.36	3.8
6/20/12	17:56	X178.9C1	181.6	178.9	3061	on-board	1200	4	24.2	C/N-0.209	0.066	17:43	296	66.9	0.23	7.52	351.8	181.6	189.8	3.00	2.71	0.2
6/21/12	12:28	X176.8C1	179.5	176.8	3061	on-board	920	4	22.0	C/N-0.212	0.089	12:17	291	~~18.1~~	~~0.06~~	8.41	~~215.9~~	231.3	~~15.5~~	~~0.74~~	9.31	12.8
6/21/12	14:40	X173.9C1	176.5	173.9	3061	on-board	980	4	25.1	C/N-0.191	0.086	14:21	323	25.7	0.08	8.07	79.7	295.8	216.2	0.98	7.74	2.2
6/21/12	16:12	X172.0C1	174.9	172.0	3061	on-board	1632	6	24.5	C/N-0.213	0.062	15:49	340	35.9	0.11	8.35	99.1	274.5	175.4	1.26	5.90	2.6
6/21/12	17:39	X170.0C1	173.1	170.0	3061	on-board	1072	4	23.5	C/N-0.225	0.015	17:18	462	77.2	0.17	8.13	96.4	280.1	183.7	2.05	4.12	3.4
6/22/12	12:56	X167.0C1	170.1	167.0	3061	on-board	1004	4	24.0	C/N-0.209	0.035	12:34	332	21.0	0.06	8.30	123.3	282.2	158.9	0.76	3.93	1.7
6/22/12	14:33	X164.5C1	164.5	164.5	3061	on-board	1096	4	23.4	C/N-0.200	0.030	14:08	362	112.3	0.31	8.19	184.1	359.2	175.1	3.79	3.60	8.6
6/25/12	14:00	X147.6C1	151.1	147.6	3061	on-board	960	4	23.6	C/N-0.181	0.007	13:48	260	13.1	0.05	8.35	134.9	282.7	147.8	0.60	5.79	3.1
6/25/12	17:15	X150.2C1	153.7	150.2	3061	on-board	888	4	21.5	C/N-0.224	0.019	16:55	303	42.4	0.14	10.23	106.6	306.6	200.1	1.37	11.26	1.2
6/26/12	13:43	X149.5C1	152.9	149.5	3061	on-board	1056	4	24.4	C/N-0.255	0.012	13:26	335	77.7	0.23	7.47	132.5	313.6	181.0	3.11	4.49	4.6
6/26/12	15:38	X148.7C1	152.1	148.7	3061	on-board	844	4	21.1	C/N-0.229	0.036	15:20	259	~~4.6~~	~~0.02~~	8.51	~~347.5~~	281.9	~~294.4~~	NR	9.69	0.9
6/26/12	18:24	X144.8C1	148.3	144.8	3061	on-board	836	4	21.8	C/N-0.222	0.029	17:45	216	38.5	0.18	8.56	116.5	269.3	152.9	2.08	8.37	9.8
6/27/12	12:04	X143.2C2	146.6	143.2	3061	on-board	728	4	22.4	C/N-0.249	0.020	10:22	222	57.5	0.26	8.96	60.3	244.1	183.8	2.89	4.05	3.5
6/27/12	12:45	X143.2C1	146.6	143.2	2837	on-board	906	6	40.4	P/P-0.198	2.416	12:30	171	~~18.3~~	~~0.11~~	4.21	~~272.4~~	273.3	~~0.8~~	~~2.54~~	15.20	9.0
6/27/12	13:51	X142.3C1	145.7	142.3	2837	on-board	808	4	22.8	C/N-0.222	0.080	13:35	234	~~53.9~~	~~0.23~~	8.18	~~240.0~~	233.4	~~353.4~~	~~2.82~~	6.01	11.7
6/27/12	14:40	X142.1C1	145.5	142.1	2837	on-board	1204	4	23.6	C/N-0.225	0.017	14:16	298	~~135.1~~	~~0.45~~	8.50	~~237.4~~	237.7	~~0.4~~	~~5.34~~	9.73	18.3
6/27/12	16:39	X141.5C1	144.9	141.5	2837	on-board	1296	4	33.5	C/N-0.158	0.246	No loop test due to a fast, shallow passage that required walking										
6/27/12	17:23	X141.5C2	144.9	141.5	2837	on-board	736	4	23.2	C/N-0.238	0.039	17:13	224	~~170.7~~	~~0.76~~	8.14	~~230.7~~	226.6	~~355.9~~	~~9.36~~	11.66	27.8
6/27/12	18:29	X140.8C2	144.3	140.8	2837	on-board	936	4	24.3	C/N-0.234	0.057	18:17	291	~~159.9~~	~~0.55~~	8.67	~~208.9~~	208.0	~~359.1~~	~~6.34~~	20.96	324.0
6/27/12	19:12	X140.8C1	144.3	140.8	2837	on-board	796	4	33.5	C/N-0.194	1.880	No loop test - lost bottom track										
6/28/12	12:17	X140.2C1	143.5	140.2	2837	off-boat	1040	4	23.7	C/N-0.202	0.056	12:04	271	34.0	0.13	7.93	34.2	219.4	185.2	1.58	4.80	0.5
6/28/12	13:20	X139.4C1	143.0	139.4	2837	off-boat	1272	4	28.1	C/P-0.214	0.007	13:01	433	~~16.6~~	~~0.04~~	7.29	~~330.5~~	259.3	~~71.2~~	~~0.00~~	9.47	4.1
6/28/12	14:27	X139.4C2	143.0	139.4	2837	off-boat	660	4	30.3	C/N-0.220	0.160	14:16	230	~~11.5~~	~~0.05~~	4.84	~~235.0~~	257.4	~~22.4~~	~~1.03~~	2.17	2.2
6/28/12	15:15	X138.9C1	142.2	138.9	2837	off-boat	920	4	23.6	C/N-0.218	0.042	15:02	290	~~4.9~~	~~0.02~~	7.85	~~134.5~~	248.3	~~113.8~~	NR	1.72	0.9
6/28/12	16:27	X138.5C1	141.9	138.5	2837	off-boat	824	4	22.1	C/N-0.227	0.014	16:16	254	20.1	0.08	7.68	50.7	232.5	181.8	1.03	2.76	1.7
6/28/12	17:41	X138.2C1	141.7	138.2	2837	off-boat	1016	4	24.7	C/N-0.229	0.027	17:21	381	9.4	0.02	8.12	48.1	223.5	175.5	NR	2.11	0.1
6/29/12	14:48	X136.7C1	140.0	136.7	2837	off-boat	744	4	22.0	C/N-0.199	0.069	14:28	231	16.1	0.07	9.60	55.5	255.9	200.4	0.73	4.33	0.7
6/29/12	16:21	X136.4C1	139.8	136.4	2837	off-boat	908	4	23.8	C/N-0.227	0.007	16:03	287	~~7.2~~	~~0.02~~	8.14	~~145.5~~	269.2	~~123.7~~	~~0.73~~	5.23	2.0
6/30/12	13:56	X135.7C1	139.0	135.7	2837	off-boat	784	4	20.6	C/N-0.237	0.043	13:39	250	~~17.1~~	~~0.07~~	7.67	~~243.4~~	194.8	~~311.4~~	~~0.89~~	2.80	2.7
6/30/12	14:51	X135.4C1	138.7	135.4	2837	off-boat	780	4	22.9	C/N-0.211	0.056	14:38	243	~~25.7~~	~~0.11~~	7.15	~~172.5~~	192.9	~~20.4~~	~~1.48~~	1.65	3.2

Date	Mid-point time	Site	Project River Mile	Brailey River Mile	Bottom Track Q, cfs	Bottom Track COV	Loop Corrected Q, cfs	Loop Corrected COV	GPS-GGA Q, cfs	GPS-GGA COV	GPS-GGA Mag var., deg NOAA	GPS-GGA Mag var., deg adjust[2]	Constant Heading Error, deg	Gold Creek Q, cfs	Moving bed uncertainty	Calculated moving bed bias	95% Uncer-tainty	Rating
6/11/12	8:25	15281000	--	Knik R.	8,986	0.004	9,580	0.005	9,365	0.001	18.6	16	2.6		0.5		4.3	Good
6/11/12	10:10	15281000	--	Knik R.	8,888	0.026	9,418	0.024	9,270	0.003	18.6	15	3.6		0.5		7.6	Fair
6/14/12	17:57	15291500	225.0	223.0	26,922	0.028	No loop test		26,932	0.002	19.5	19	0.5	42600	0.5		4.0	Good
6/16/12	18:35	X176.1C1	178.5	176.1	29,275	0.021	No loop test		29,756	0.011	19.1	19.1	0.0	36900	0.5		2.1	Good
6/17/12	16:30	X184.1C1	187.2	184.1	27,619	0.064	No loop test		27,698	0.071	19.2	19.2	0.0	32800	0.5		8.1	Poor
6/18/12	14:13	X183.4C1	186.2	183.4	23,922	0.019	24,372	0.020	24,493	0.017	19.2	15	4.2	32200	0.5		3.0	Good
6/18/12	16:10	X182.8C1	185.5	182.8	24,325	0.012	25,389	0.014	24,580	0.012278895	19.2	16	3.2	32300	0.5		2.7	Good
6/19/12	12:04	X182.6C3	185.2	182.6	7,680	0.025	Bad bottom track		7,712	0.006	19.2	22	-2.8	34400	1.5	***1.3***	4.0	Good
6/19/12	13:02	X182.6C1	185.2	182.6	1,193	0.030	NR - bed v £ 0.04		1,172	0.023	19.2	20	-0.8	34900			4.1	Good
6/19/12	13:54	X182.6C2	185.2	182.6	17,508	0.061	Bad bottom track		17,771	0.07	19.2	16	3.2	35300	1.5	1.3	11.7	Poor
6/19/12	15:49	X182.2C1	184.9	182.2	27,058	0.004	Bad bottom track		27,619	0.007	19.2	19.2	0.0	35500	1.5	1.1	4.0	Good
6/19/12	16:51	X181.7C1	184.4	181.7	27,886	0.035	Invalid closure		27,419	0.024	19.2	3	16.2	35500	1.5	0.9	7.1	Fair
6/20/12	13:19	X180.3C1	183.3	180.3	29,426	0.028	Invalid closure		29,101	0.012446284	19.1	15	4.1	36300	1.5	0.2	5.5	Fair
6/20/12	15:03	X179.8C1	182.9	179.8	5,496	0.032	Invalid closure		5,456	0.006	19.1	15	4.1	36400	1.5	***1.1***	7.0	Fair
6/20/12	16:58	X179.8C2	182.9	179.8	23,317	0.007	23,633	0.007	22,969	0.002	19.1	17	2.1	36300	0.5		1.8	Excellent
6/20/12	17:56	X178.9C1	181.6	178.9	28,688	0.006	29,645	0.004	28,793	0.001	19.1	20	-0.9	36200	0.5		1.5	Excellent
6/21/12	12:28	X176.8C1	179.5	176.8	30,866	0.023	Invalid closure		29,802	0.006	19.1	15	4.1	37500	1.5	1.3	6.0	Fair
6/21/12	14:40	X173.9C1	176.5	173.9	31,186	0.005	<1% correction		31,240	0.003	19.2	21	-1.8	37500	0.5		1.4	Excellent
6/21/12	16:12	X172.0C1	174.9	172.0	30,711	0.018	31,163	0.018	30,937	0.009	19.1	8	11.1	37300	0.5		2.8	Good
6/21/12	17:39	X170.0C1	173.1	170.0	29,815	0.017	30,571	0.017	30,420	0.009	19.1	7	12.1	37000	0.5		3.0	Good
6/22/12	12:56	X167.0C1	170.1	167.0	31,121	0.009	<1% correction		30,827	0.004	19.0	9	10.0	36700	0.5		2.1	Good
6/22/12	14:33	X164.5C1	164.5	164.5	30,943	0.010	32,265	0.010	31,643	0.003	19.0	11	8.0	36700	0.5		2.2	Good
6/25/12	14:00	X147.6C1	151.1	147.6	33,180	0.014	<1% correction		33,180	0.014	18.9	8	10.9	36400	0.5		2.7	Good
6/25/12	17:15	X150.2C1	153.7	150.2	31,596	0.010	32,162	0.010	31,114	0.008	18.9	6	12.9	35900	0.5		2.2	Good
6/26/12	13:43	X149.5C1	152.9	149.5	29,361	0.032	30,487	0.034	29,997	0.017	18.9	14	4.9	35800	0.5		5.1	Fair
6/26/12	15:38	X148.7C1	152.1	148.7	30,036	0.017	NR - bed v £ 0.04		29,980	0.014	18.9	11	7.9	36000			2.5	Good
6/26/12	18:24	X144.8C1	148.3	144.8	31,328	0.015	32,114	0.015	31,067	0.012	18.8	9	9.8	35600	0.5		2.8	Good
6/27/12	12:04	X143.2C2	146.6	143.2	29,724	0.020	Invalid closure		28,504	0.01	18.8	5	13.8	34400	1.5	2.4	6.8	Fair
6/27/12	12:45	X143.2C1	146.6	143.2	1,306	0.039	Invalid closure		1,264	0.026	18.8	16	2.8	34400			4.4	Good
6/27/12	13:51	X142.3C1	145.7	142.3	31,396	0.010	Invalid closure		30,120	0.005	18.8	12	6.8	34500	1.5	2.2	5.4	Fair
6/27/12	14:40	X142.1C1	145.5	142.1	31,868	0.009	Invalid closure		29,894	0.02	18.8	15	3.8	34800	1.5	2.2	5.3	Fair
6/27/12	16:39	X141.5C1	144.9	141.5	7,621	0.025	No loop test		7,338	0.012	18.8	20	-1.2	35100	1.5	2.1	7.1	Fair
6/27/12	17:23	X141.5C2	144.9	141.5	24,328	0.011	Invalid closure		22,373	0.011	18.8	11	7.8	35200	1.5	2.1	5.4	Fair
6/27/12	18:29	X140.8C2	144.3	140.8	28,728	0.011	Invalid closure		25,413	0.015	18.8	29	-10.2	35000	1.5		3.3	Good
6/27/12	19:12	X140.8C1	144.3	140.8	2,379	0.028	Lost bottom track		2,393	0.012	18.8	18.8	0.0	35000	0.5		2.4	Good
6/28/12	12:17	X140.2C1	143.5	140.2	29,703	0.004	30,330	0.003	29,767	0.011	18.8	19	-0.2	32900	0.5		1.4	Excellent
6/28/12	13:20	X139.4C1	143.0	139.4	24,720	0.015	NR - bed v £ 0.04		24,503	0.006	18.8	18.8	0.0	32900			2.3	Good
6/28/12	14:27	X139.4C2	143.0	139.4	4,772	0.010	Invalid closure		4,723	0.013	18.8	18.8	0.0	33100			1.7	Excellent
6/28/12	15:15	X138.9C1	142.2	138.9	29,753	0.016	NR - bed v £ 0.04		29,602	0.01	18.8	19	-0.2	33200			2.4	Good
6/28/12	16:27	X138.5C1	141.9	138.5	30,161	0.012	30,583	0.012	30,109	0.004	18.8	19	-0.2	33200	0.5		2.4	Good
6/28/12	17:41	X138.2C1	141.7	138.2	30,239	0.012	NR - bed v £ 0.04		30,555	0.008	18.8	18	0.8	33300			1.5	Excellent
6/29/12	14:48	X136.7C1	140.0	136.7	30,378	0.005	<1% correction		29,900	0.005	18.8	25	-6.2	32300			1.1	Excellent
6/29/12	16:21	X136.4C1	139.8	136.4	29,071	0.011	NR - bed v £ 0.04		28,786	0.008	18.8	18.8	0.0	32200			1.8	Excellent
6/30/12	13:56	X135.7C1	139.0	135.7	28,039	0.013	Invalid closure		27,609	0.012	18.7	19	-0.3	31000			2.1	Good
6/30/12	14:51	X135.4C1	138.7	135.4	28,230	0.007	Invalid closure		27,696	0.004	18.7	19	-0.3	31000			1.3	Excellent

Date	Mid-point time	Site	Project River Mile	Brailey River Mile	ADCP Serial No.	Compass Calibration	Mmt duration, s	No. of Transects	% Top & Bottom Est's	Extrapolation Settings1	% Edge Est's.	Loop Test Results										
												Start time	Duration, s	DMG, ft	Velocity, ft/s: Bed	Velocity, ft/s: Flow	Direction, deg: Bed	Direction, deg: Flow	Direction, deg: Diff	% Corr	% bad BT	out-back difference
6/30/12	15:53	X134.7C1	138.1	134.7	2837	off-boat	1156	4	37.7	P/P-0.172	0.33	No loop test because C2 channel shows stationary bed										
6/30/12	17:13	X134.7C2	138.1	134.7	2837	off-boat	808	4	24.1	C/N-0.201	0.126	16:57	263	~~9.0~~	~~0.03~~	7.96	~~201.3~~	199.9	~~358.6~~	NR	1.14	3.5
6/30/12	18:13	X134.3C1	137.6	134.3	2837	off-boat	920	4	23.6	C/N-0.220	0.040	17:57	307	~~34.8~~	~~0.11~~	7.07	~~202.6~~	213.6	~~11.0~~	~~1.60~~	0.33	3.7
7/1/12	13:35	X133.3C1	136.7	133.3	2837	off-boat	1084	4	27.0	C/N-0.204	0.067	13:10	391	~~151.6~~	~~0.39~~	6.38	~~220.7~~	210.5	~~349.9~~	~~6.07~~	10.74	12.0
7/1/12	15:15	X132.9C2	136.2	132.9	2837	off-boat	812	4	30.1	C/N-0.181	0.803	14:55	303	~~86.9~~	~~0.29~~	6.23	~~230.9~~	209.0	~~338.1~~	~~4.61~~	1.32	7.7
7/1/12	16:57	X132.9C1	136.2	132.9	2837	off-boat	684	4	25.8	C/N-0.222	0.134	16:48	192	20.0	0.10	7.11	29.6	208.2	178.6	1.46	2.08	1.1
7/1/12	18:17	X131.8C1	135.0	131.8	2837	off-boat	692	4	22.7	C/N-0.223	0.013	18:02	274	11.2	0.04	7.11	70.2	251.9	181.7	0.57	2.55	0.6
7/1/12	18:48	X131.8C2	135.0	131.8	2837	off-boat	820	4	33.9	C/N-0.198	0.629	No loop test - small channel. Mean H2O velocity 1.3 ft/s, bed probably not moving										
7/2/12	12:16	X131.2C1	134.3	131.2	2837	off-boat	860	4	24.0	C/N-0.232	0.048	12:03	275	~~5.8~~	~~0.02~~	7.37	~~161.0~~	269.3	~~108.3~~	NR	0.73	1.1
7/2/12	13:18	X130.9C1	134.1	130.9	2837	off-boat	648	4	21.4	C/N-0.185	0.034	13:08	222	~~2.9~~	~~0.01~~	7.08	~~280.5~~	252.7	~~332.2~~	NR	3.60	0.5
7/2/12	14:30	X130.5C2	133.8	130.5	2837	off-boat	668	4	24.2	C/N-0.220	0.063	14:00	198	~~20.2~~	~~0.10~~	7.43	~~261.9~~	252.3	~~350.4~~	~~1.37~~	1.01	2.6
7/2/12	15:18	X130.5C1	133.8	130.5	2837	off-boat	436	4	39.8	C/N-0.250	1.74	No loop test - small channel. Mean H2O velocity 2.7 ft/s, bed probably not moving										
7/2/12	16:22	X130.0C2	133.3	130.0	2837	off-boat	2212	4	25.8	C/N-0.176	0.062	No loop test due to a wide, shallow bar that required walking										
7/2/12	17:57	X129.4C1	132.6	129.4	2837	off-boat	996	4	28.1	C/N-0.207	0.049	17:43	336	~~8.6~~	~~0.03~~	6.19	~~237.0~~	212.9	~~335.9~~	NR	1.49	2.1
7/3/12	13:11	X130.0C1	133.3	130.0	2837	off-boat	708	4	46.9	C/N-0.226	2.59	No loop test - small channel. Mean H2O velocity 2.5 ft/s, bed probably not moving										
7/3/12	14:31	X128.1C1	131.4	128.1	2837	off-boat	2380	4	27.2	C/N-0.191	0.035	No loop test due to fast shallows requiring 2 people to walk the boat										
7/3/12	16:23	X128.1C2	131.4	128.1	2837	off-boat	780	4	39.8	C/N-0.178	0.382	16:11	201	1.7	0.01	4.66	6.2	211.3	205.1	NR	0.50	1.2
7/3/12	17:33	X126.6C1	129.7	126.6	2837	off-boat	916	4	22.5	C/N-0.194	0.03	17:17	304	18.4	0.06	6.63	30.0	228.1	198.1	0.91	1.97	0.5
7/4/12	15:40	X124.4C1	128.1	124.4	2837	off-boat	1108	4	26.8	C/N-0.240	0.10	16:07	338	40.6	0.12	5.66	357.5	209.2	211.8	2.12	7.1*	0.3
7/4/12	17:22	X123.3C1	126.8	123.3	2837	off-boat	896	4	20.9	C/N-0.220	0.11	17:10	294	36.6	0.12	6.78	13.3	208.1	194.8	1.83	1.36	2.5
7/5/12	13:51	X122.6C2	126.1	122.6	2837	off-boat	684	4	24.4	C/N-0.212	0.02	13:41	249	64.9	0.26	7.07	16.0	204.8	188.8	3.69	3.21	5.0
7/5/12	14:56	X122.6C1	126.1	122.6	2837	off-boat	488	4	31.2	C/N-0.236	1.96	No loop test - small channel. Mean H2O velocity 1.3 ft/s, bed probably not moving										
7/5/12	16:06	X121.8C2	125.4	121.8	2837	off-boat	816	4	26.0	C/N-0.186	0.02	15:48	302	74.1	0.25	6.86	22.2	206.3	184.1	3.57	2.98	6.5
7/5/12	17:11	X121.8C1	125.4	121.8	2837	off-boat	572	4	35.8	C/N-0.192	0.62	17:00	180	23.8	0.13	5.40	15.4	201.0	185.6	2.45	1.11	6.2
7/5/12	18:11	X120.7C1	124.1	120.7	2837	off-boat	988	4	23.6	C/N-0.184	0.03	17:55	263	53.3	0.20	6.96	35.6	219.1	183.5	2.91	2.28	3.3
7/6/12	11:47	X120.3C1	123.7	120.3	2837	off-boat	784	4	25.7	C/N-0.212	0.12	11:29	219	~~99.5~~	~~0.45~~	5.48	~~18.1~~	203.3	185.1	~~8.29~~	0.91	9.3
7/6/12	12:49	X120.3C2	123.7	120.3	2837	off-boat	560	4	23.6	C/N-0.239	0.25	12:41	193	10.6	0.05	4.25	43.3	220.7	177.4	1.29	0.00	2.8
7/6/12	14:23	X119.3C1	122.7	119.3	2837	off-boat	900	4	25.2	C/N-0.185	0.02	14:10	324	47.9	0.15	5.68	12.2	207.7	195.6	2.60	0.93	2.1
7/6/12	15:12	X119.2C2	122.6	119.2	2837	off-boat	716	4	21.8	C/N-0.252	0.08	15:01	233	28.2	0.12	6.75	11.3	195.5	184.2	1.79	1.29	1.6
7/6/12	15:59	X119.2C1	122.6	119.2	2837	off-boat	536	4	37.7	C/N-0.104	2.22	15:44	176	4.7	0.03	2.37	20.9	194.5	173.6	NR	0.00	1.7
7/6/12	16:44	X117.2C2	120.7	117.2	2837	off-boat	756	4	26.4	C/N-0.203	0.20	16:35	225	22.3	0.10	6.31	41.9	228.1	186.1	1.57	0.89	2.8
7/6/12	17:55	X117.2C1	120.7	117.2	2837	off-boat	708	4	24.3	C/N-0.227	0.07	17:44	217	19.0	0.09	6.81	19.4	203.5	184.1	1.28	1.84	3.0
7/7/12	12:19	X116.4C1	119.9	116.4	2837	off-boat	696	4	22.5	C/N-0.216	0.10	12:03	238	~~7.9~~	~~0.03~~	6.54	~~173.4~~	215.6	~~42.1~~	NR	0.42	0.8
7/7/12	13:09	X115.0C2	118.4	115.0	2837	off-boat	696	4	23.7	C/N-0.219	0.04	12:58	249	~~7.0~~	~~0.03~~	6.57	~~234.0~~	184.1	~~310.1~~	NR	1.61	1.5
7/7/12	15:03	X115.0C1	118.4	115.0	2837	off-boat	820	4	27.8	C/N-0.175	0.59	No loop test - small channel. Mean H2O velocity 0.72 ft/s, bed probably not moving										
7/7/12	15:50	X114.0C1	117.4	114.0	2837	off-boat	1140	4	38.2	C/N-0.093	0.77	No loop test - small channel. Mean H2O velocity 2.2 ft/s, bed probably not moving										
7/7/12	16:40	X114.0C2	117.4	114.0	2837	off-boat	728	4	23.8	C/N-0.219	0.06	16:25	228	~~13.1~~	~~0.06~~	7.24	~~253.2~~	180.9	~~287.7~~	~~0.80~~	1.75	1.9
7/7/12	17:36	X113.0C1	116.6	113.0	2837	off-boat	1028	4	23.9	C/N-0.187	0.02	17:20	379	~~15.1~~	~~0.04~~	5.97	~~172.6~~	182.4	~~9.8~~	~~0.67~~	1.06	1.6
7/8/12	12:42	X112.7C1	116.3	112.7	2837	off-boat	924	4	27.9	C/N-0.195	0.07	12:26	248	15.9	0.06	6.38	24.6	180.3	155.7	1.01	1.61	1.4
7/8/12	13:41	X112.2C2	115.7	112.2	2837	off-boat	1056	4	38.9	C/N-0.167	0.34	13:27	373	28.4	0.08	4.97	330.9	135.7	164.8	1.53	0.27	4.9
7/8/12	14:29	X112.2C1	115.7	112.2	2837	off-boat	804	4	22.8	C/N-0.248	0.05	14:18	266	34.1	0.13	6.86	7.2	174.3	167.1	1.87	0.38	0.7
7/8/12	15:45	X111.8C2	115.4*	111.8	2837	off-boat	736	4	23.7	C/N-0.225	0.05	15:32	253	42.9	0.17	7.21	354.5	168.5	174.0	2.35	5.14	3.0
7/8/12	16:41	X111.8C1	115.4*	111.8	2837	off-boat	600	4	28.0	C/N-0.224	0.55	16:25	165	12.9	0.08	3.49	7.5	172.2	164.7	2.24	1.82	2.7
7/8/12	18:01	X110.9C1	114.4	110.9	2837	off-boat	756	4	29.4	C/N-0.220	0.39	17:51	245	37.9	0.15	5.54	321.3	157.9	196.5	2.80	10.61	1.3
7/8/12	18:57	X110.9C2	114.4	110.9	2837	off-boat	792	4	21.6	C/N-0.214	0.08	18:43	216	18.4	0.09	7.89	320.5	131.6	171.1	1.08	0.46	1.3

Date	Mid-point time	Site	Project River Mile	Brailey River Mile	Bottom Track		Loop Corrected		GPS-GGA				Constant Heading Error, deg	Gold Creek Q, cfs	Moving bed uncertainty	Calculated moving bed bias	95% Uncer-tainty	Rating
					Q, cfs	COV	Q, cfs	COV	Q, cfs	COV	Mag var., deg NOAA	Mag var., deg adjust[2]						
6/30/12	15:53	X134.7C1	138.1	134.7	4,805	0.018	No loop test		4,718	0.009	18.7	18	0.7	31000			2.7	Good
6/30/12	17:13	X134.7C2	138.1	134.7	23,398	0.011	NR - bed v £ 0.04		23,103	0.007	18.7	20	-1.3	31000			1.8	Excellent
6/30/12	18:13	X134.3C1	137.6	134.3	27,893	0.006	Invalid closure		27,417	0.003	18.7	18.7	0.0	31000	1.5	0.9	3.6	Good
7/1/12	13:35	X133.3C1	136.7	133.3	26,756	0.007	Invalid closure		24,213	0.012	18.7	24	-5.3	30000	1.5	1.4	4.2	Good
7/1/12	15:15	X132.9C2	136.2	132.9	11,953	0.011	Invalid closure		11,033	0.02	18.7	20	-1.3	30000	1.5	***1.5***	4.8	Good
7/1/12	16:57	X132.9C1	136.2	132.9	14,734	0.007	14,990	0.006	14,825	0.009	18.7	18	0.7	29900	0.5		1.7	Excellent
7/1/12	18:17	X131.8C1	135.0	131.8	25,989	0.009	NR - bed v £ 0.04		25,486	0.008	18.7	18.7	0.0	29700			1.6	Excellent
7/1/12	18:48	X131.8C2	135.0	131.8	537	0.004	No loop test		514	0.019	18.7	16	2.7	29700			1.0	Excellent
7/2/12	12:16	X131.2C1	134.3	131.2	25,463	0.014	NR - bed v £ 0.04		25,183	0.004	18.7	17	1.7	28000			2.2	Good
7/2/12	13:18	X130.9C1	134.1	130.9	26,166	0.021	NR - bed v £ 0.04		25,782	0.008	18.7	18.7	0.0	27900			3.0	Good
7/2/12	14:30	X130.5C2	133.8	130.5	25,100	0.015	Invalid closure		24,592	0.01	18.7	18	0.7	28000			2.3	Good
7/2/12	15:18	X130.5C1	133.8	130.5	615	0.040	No loop test		606	0.003	18.7	18	0.7	28000			5.3	Fair
7/2/12	16:22	X130.0C2	133.3	130.0	24,799	0.009	No loop test		24,450	0.003	18.7	18	0.7	27900			1.6	Excellent
7/2/12	17:57	X129.4C1	132.6	129.4	25,046	0.008	NR - bed v £ 0.04		24,964	0.003	18.7	18.7	0.0	27800			1.5	Excellent
7/3/12	13:11	X130.0C1	133.3	130.0	840	0.054	No loop test		879	0.019	18.7	18.7	0.0	31100			2.8	Good
7/3/12	14:31	X128.1C1	131.4	128.1	25,331	0.017	No loop test		26,583	0.034	18.7	18.7	0.0	31200			4.6	Good
7/3/12	16:23	X128.1C2	131.4	128.1	2,045	0.006	NR - bed v £ 0.04		GPS ship tracks incorrect					31000			1.2	Excellent
7/3/12	17:33	X126.6C1	129.7	126.6	28,243	0.016	<1% correction		28,233	0.006	18.7	18.7	0.0	30900			2.4	Good
7/4/12	15:40	X124.4C1	128.1	124.4	26,325	0.011	Lost bottom track		26,748	0.008	18.6	19	-0.4	30000	0.5		2.0	Good
7/4/12	17:22	X123.3C1	126.8	123.3	26,960	0.008	27,608	0.007	27,183	0.003	18.6	20	-1.4	29900	0.5		1.8	Excellent
7/5/12	13:51	X122.6C2	126.1	122.6	25,938	0.013	27,028	0.013	26,791	0.009	18.6	21	-2.4	28800	0.5		2.6	Good
7/5/12	14:56	X122.6C1	126.1	122.6	215	0.015	No loop test		220	0.021	18.6	19	-0.4	28600			3.0	Good
7/5/12	16:06	X121.8C2	125.4	121.8	22,027	0.001	22,996	0.001	22,796	0.003	18.6	20	-1.4	28500	0.5		1.1	Excellent
7/5/12	17:11	X121.8C1	125.4	121.8	3,333	0.017	3,430	0.016	3,428	0.012	18.6	20	-1.4	28200	0.5		2.9	Good
7/5/12	18:11	X120.7C1	124.1	120.7	25,086	0.027	26,132	0.026	25,927	0.009	18.6	22	-3.4	27900	0.5		4.1	Good
7/6/12	11:47	X120.3C1	123.7	120.3	18,274	0.004	bad out-back Ð		19,515	0.005	18.6	20	-1.4	24700	0.5		1.6	Excellent
7/6/12	12:49	X120.3C2	123.7	120.3	4,295	0.009	4,360	0.009	4,350	0.006	18.6	16	2.6	24500	0.5		2.1	Good
7/6/12	14:23	X119.3C1	122.7	119.3	22,510	0.006	23,331	0.007	22,932	0.009	18.6	16	2.6	24100	0.5		1.8	Excellent
7/6/12	15:12	X119.2C2	122.6	119.2	21,715	0.017	22,260	0.018	22,132	0.006	18.6	15	3.6	24000	0.5		3.2	Good
7/6/12	15:59	X119.2C1	122.6	119.2	629	0.015	NR - bed v £ 0.04		630	0.014	18.6	16	2.6	23600			2.2	Good
7/6/12	16:44	X117.2C2	120.7	117.2	11,031	0.015	11,214	0.015	11,144	0.004	18.6	16	2.6	23400	0.5		2.8	Good
7/6/12	17:55	X117.2C1	120.7	117.2	11,286	0.009	11,472	0.009	11,308	0.009	18.6	15	3.6	23100	0.5		2.1	Good
7/7/12	12:19	X116.4C1	119.9	116.4	20,715	0.012	NR - bed v £ 0.04		20,580	0.006	18.6	14	4.6	21600			1.9	Excellent
7/7/12	13:09	X115.0C2	118.4	115.0	20,345	0.005	NR - bed v £ 0.04		20,269	0.003	18.6	16	2.6	21600			1.1	Excellent
7/7/12	15:03	X115.0C1	118.4	115.0	311	0.008	No loop test		285	0.007	18.6	16	2.6	21200			1.5	Excellent
7/7/12	15:50	X114.0C1	117.4	114.0	1,808	0.006	No loop test		1,763	0.013	18.6	15	3.6	21100			1.2	Excellent
7/7/12	16:40	X114.0C2	117.4	114.0	18,939	0.007	Invalid closure		18,842	0.002	18.6	16	2.6	21000			1.3	Excellent
7/7/12	17:36	X113.0C1	116.6	113.0	20,665	0.011	NR - bed v £ 0.04		20,415	0.007	18.6	16	2.6	21000			1.8	Excellent
7/8/12	12:42	X112.7C1	116.3	112.7	23,766	0.011	24,060	0.011	24,092	0.006	18.5	18	0.5	28600	0.5		1.7	Excellent
7/8/12	13:41	X112.2C2	115.7	112.2	6,442	0.007	6,557	0.006	6,556	0.01	18.5	17	1.5	28900	0.5		1.7	Excellent
7/8/12	14:29	X112.2C1	115.7	112.2	18,089	0.004	18,449	0.005	18,243	0.002	18.5	18.5	0.0	29100	0.5		1.6	Excellent
7/8/12	15:45	X111.8C2	115.4*	111.8	22,918	0.006	23,538	0.006	23,180	0.006	18.5	18	0.5	29100	0.5		1.7	Excellent
7/8/12	16:41	X111.8C1	115.4*	111.8	2,354	0.014	2,420	0.016	2,381	0.005	18.5	18	0.5	29100	0.5		2.9	Good
7/8/12	18:01	X110.9C1	114.4	110.9	6,096	0.006	6,308	0.008	6,336	0.005	18.5	17	1.5	29100	0.5		1.6	Excellent
7/8/12	18:57	X110.9C2	114.4	110.9	19,216	0.005	19,457	0.006	19,525	0.003	18.5	16	2.5	28900	0.5		1.4	Excellent

Date	Mid-point time	Site	Project River Mile	Brailey River Mile	ADCP Serial No.	Compass Calibration	Mmt duration, s	No. of Transects	% Top & Bottom Est's	Extrapolation Settings1	% Edge Est's.	Loop Test Results: Start time	Duration, s	DMG, ft	Velocity, ft/s: Bed	Velocity, ft/s: Flow	Direction, deg: Bed	Direction, deg: Flow	Direction, deg: Diff	% Corr	% bad BT	out-back difference
7/9/12	14:23	X110.0C1	113.6	110.0	2837	off-boat	876	4	22.6	C/N-0.223	0.02	14:10	267	29.0	0.11	6.77	354.1	192.2	198.2	1.60	1.50	1.7
7/9/12	15:23	X108.4C1	111.9	108.4	2837	off-boat	876	4	23.3	C/N-0.223	0.02	15:09	290	15.9	0.05	6.81	347.7	203.4	215.7	0.80	1.03	0.1
7/9/12	16:46	X106.7C1	110.5	106.7	2837	off-boat	992	4	24.4	C/N-0.219	0.05	16:11	323	26.3	0.08	6.92	17.5	200.6	183.1	1.18	3.41	1.3
7/9/12	18:26	X103.0C1	107.1	103	2837	off-boat	856	4	22.8	C/N-0.209	0.07	18:10	245	43.3	0.18	7.32	0.2	183.6	183.4	2.41	2.04	1.8
7/10/12	12:59	X98.8C2	--	98.8	2837	off-boat	704	4	28.5	C/N-0.174	1.04	No loop test - small channel. Mean H2O velocity 2.2 ft/s, bed probably not moving										
7/10/12	14:01	X98.8C1	--	98.8	2837	off-boat	792	4	29.5	C/N-0.209	0.05	13:48	275	77.8	0.28	6.25	46.5	201.2	154.7	4.53	14.55	4.5
7/10/12	14:38	X98.8C3	--	98.8	2837	off-boat	528	4	24.7	C/N-0.197	0.25	No loop test - small channel. Mean H2O velocity 2.8 ft/s, bed probably not moving										
7/10/12	16:08	X98.0C5	101.4	98.0	2837	off-boat	760	4	24.5	C/N-0.197	0.321	15:44	203	36.5	0.18	6.36	10.6	201.5	190.9	2.83	4.43	2.2
7/11/12	12:32	X95.0C1	98.4	95.0	2837	off-boat	904	4	23.5	C/N-0.168	0.023	12:12	284	103.8	0.37	6.77	354.2	183.7	189.5	5.40	6.71	1.8
7/11/12	13:36	X95.0C2	98.4	95.0	2837	off-boat	688	4	26.1	C/N-0.20	0.711	13:22	180	12.1	0.07	2.20	11.1	191.7	180.6	3.04	1.12	3.8
7/11/12	16:19	X95.0C4	98.4	95.0	2837	off-boat	936	4	37.4	C/N-0.207	0.500	16:04	254	~~18.5~~	~~0.07~~	0.70	~~197.6~~	195.1	~~357.5~~	~~10.35~~	0.00	7.2
7/11/12	17:48	X94.0C2	97.0	94.0	2837	off-boat	996	4	26.7	C/N-0.178	0.088	17:25	339	89.4	0.26	6.79	39.4	245.1	205.7	3.88	2.06	5.5
7/11/12	19:06	X94.0C1	97.0	94.0	2837	off-boat	840	4	24.2	C/N-0.178	0.071	18:55	247	21.5	0.09	5.16	18.7	194.0	175.3	1.69	1.21	3.7
7/12/12	14:43	X86.9C2	91.0	86.9	2837	off-boat	1548	4	25.8	C/N-0.150	0.015	14:20	291	58.7	0.20	5.93	7.3	192.7	185.5	3.40	3.09	1.0
7/12/12	15:55	X86.9C1	91.0	86.9	2837	off-boat	416	4	41.8	C/N-0.161	3.731	15:46	153	~~2.3~~	~~0.01~~	3.58	~~335.6~~	202.0	~~226.4~~	NR	1.32	1.2
7/12/12	16:20	X86.9C1.5	91.0	86.9	2837	off-boat	624	4	31.6	C/N-0.181	3.260	No loop test - small channel. Mean H2O velocity 1.4 ft/s, bed probably not moving										
7/12/12	17:30	X83.0C2	87.1	83.0	2837	off-boat	936	4	23.5	C/N-0.212	0.263	17:14	311	43.3	0.14	6.76	357.6	181.3	183.7	2.06	8.36	2.9
7/12/12	18:30	X83.0C1	87.1	83.0	2837	off-boat	1148	4	26.8	C/N-0.171	0.073	18:12	399	55.1	0.14	4.96	337.1	150.4	173.3	2.79	2.26	3.7
7/13/12	12:46	X82.0C1	86.3	82.0	2837	off-boat	828	4	27.5	C/N-0.212	0.264	12:31	285	35.5	0.12	3.46	322.1	140.8	178.8	3.61	0.00	2.4
7/13/12	13:40	X82.0C2	86.3	82.0	2837	off-boat	1012	4	25.6	C/N-0.192	0.066	13:22	390	73.7	0.19	6.57	334.5	150.5	175.9	2.88	8.4*	2.7
7/13/12	15:29	X79.0C2	83.0	79.0	2837	off-boat	1508	4	27.7	C/N-0.215	0.009	15:07	448	11.2	0.02	5.22	86.3	225.2	138.9	NR	12.75	0.4
7/13/12	16:48	X79.0C1	83.0	79.0	2837	off-boat	884	4	24.0	C/N-0.200	0.165	16:32	296	64.9	0.22	6.16	328.0	139.6	171.6	3.56	3.39	3.6
8/6/12	16:13	X184.1C1	187.2	184.1	3061	off-boat	752	4	23.7	C/N-0.271	0.043	No compass calibration - Bluetooth failure.										
8/6/12	17:05	X183.4C1	186.2	183.4	3061	off-boat	856	4	23.7	C/N-0.236	0.038	No compass calibration - Bluetooth failure.										
8/6/12	18:24	X182.2C1	184.9	182.2	3061	off-boat	904	4	24.0	C/N-0.236	0.164	No compass calibration - Bluetooth failure.										
8/7/12	12:38	X181.7C1	184.4	181.7	3061	off-boat	860	4	23.8	C/N-0.234	0.171	12:22	235	9.1	0.04	6.84	121.4	267.8	146.4	NR	3.40	1.1
8/7/12	13:35	X180.3C1	183.3	180.3	3061	off-boat	840	4	23.5	C/N-0.259	0.039	13:14	376	9.0	0.02	5.02	61.8	252.6	190.8	NR	0.53	1.5
8/7/12	14:44	X178.9C1	181.6	178.9	3061	off-boat	884	4	24.0	C/N-0.227	0.066	14:31	343	41.0	0.12	5.34	357.6	175.3	177.7	2.24	0.29	1.3
8/7/12	15:41	X176.8C1	179.5	176.8	3061	off-boat	836	4	23.2	C/N-0.231	0.094	15:28	297	14.6	0.05	6.65	47.0	231.2	184.2	0.74	0.34	0.1
8/7/12	16:37	X176.1C1	178.5	176.1	3061	off-boat	908	4	24.1	C/N-0.215	0.155	16:24	340	39.6	0.12	6.35	358.0	186.2	188.2	1.83	0.59	3.1
8/8/12	12:07	X173.9C1	176.5	173.9	3061	off-boat	928	4	24.1	C/N-0.214	0.091	11:55	327	~~8.5~~	~~0.03~~	5.89	~~198.0~~	293.6	~~95.6~~	NR	0.59	1.5
8/8/12	15:16	X167.0C1	170.1	167.0	3061	off-boat	812	4	22.6	C/N-0.240	0.080	15:04	297	8.2	0.03	5.86	102.7	283.0	180.4	NR	1.01	0.0
8/8/12	16:03	X164.5C1	168.1	164.5	3061	off-boat	780	4	26.1	C/N-0.243	0.042	15:51	309	16.7	0.05	6.34	178.8	358.8	180.0	0.85	1.29	0.8
8/9/12	15:03	15291500	225.0	223.0	3061	off-boat	960	4	25.1	C/N-0.237	0.094	14:50	346	30.1	0.09	6.60	33.4	212.5	179.0	1.32	1.16	1.2
8/10/12	15:03	X150.2C1	153.7	150.2	3061	off-boat	744	4	24.0	C/N-0.243	0.073	14:53	252	~~10.6~~	~~0.04~~	7.44	~~274.1~~	305.5	~~31.4~~	~~0.57~~	0.40	3.7
8/10/12	16:07	X148.7C1	152.1	148.7	3061	off-boat	928	4	21.9	C/N-0.242	0.061	15:54	321	~~20.1~~	~~0.06~~	5.83	~~285.1~~	282.6	~~357.5~~	~~1.08~~	1.87	3.3
8/10/12	18:03	X144.8C1	148.3	144.8	3061	off-boat	880	4	23.4	C/N-0.244	0.155	17:50	342	~~16.7~~	~~0.05~~	6.46	~~283.0~~	269.5	~~346.5~~	~~0.76~~	1.46	2.7
8/12/12	13:12	X142.3C1	146.6	142.3	3061	off-boat	768	4	24.9	C/N-0.205	0.093	12:57	296	~~14.3~~	~~0.05~~	6.65	~~235.4~~	230.2	~~354.8~~	~~0.73~~	0.68	2.4
8/12/12	14:58	X140.2C1	143.5	140.2	3061	off-boat	840	4	23.8	C/N-0.235	0.125	14:46	349	~~8.3~~	~~0.02~~	6.28	~~180.1~~	222.3	~~42.2~~	NR	0.29	1.7
8/12/12	16:29	X138.9C1	142.2	138.9	3061	off-boat	936	4	27.8	C/N-0.200	0.097	16:07	349	~~21.8~~	~~0.05~~	6.38	~~229.7~~	247.3	~~17.5~~	~~0.85~~	0.25	1.3
8/12/12	17:13	X138.5C1	141.9	138.5	3061	off-boat	896	4	23.4	C/N-0.250	0.077	16:59	339	~~4.9~~	~~0.01~~	5.94	~~233.0~~	235.6	~~2.6~~	NR	0.88	1.4
8/13/12	12:54	X136.7C1	140.0	136.7	3061	off-boat	816	4	23.1	C/N-0.230	0.087	12:36	384	~~6.2~~	~~0.02~~	7.25	~~9.1~~	254.9	~~245.8~~	NR	1.04	2.2
8/13/12	13:58	X135.7C1	139.0	135.7	3061	off-boat	788	4	19.6	C/N-0.286	0.064	13:45	321	~~6.4~~	~~0.02~~	5.80	~~233.9~~	192.1	~~318.3~~	NR	2.80	2.5
8/13/12	14:48	X135.4C1	138.7	135.4	3061	off-boat	780	4	23.9	C/N-0.228	0.057	14:35	325	~~20.4~~	~~0.06~~	5.16	~~173.8~~	194.9	~~21.1~~	~~1.22~~	0.31	2.6
8/13/12	16:14	X134.3C1	137.6	134.3	3061	off-boat	936	4	27.3	C/N-0.209	0.059	15:58	423	~~45.0~~	~~0.11~~	5.64	~~213.8~~	214.2	~~0.4~~	~~1.88~~	0.71	4.5

Date	Mid-point time	Site	Project River Mile	Brailey River Mile	Bottom Track Q, cfs	Bottom Track COV	Loop Corrected Q, cfs	Loop Corrected COV	GPS-GGA Q, cfs	GPS-GGA COV	GPS-GGA Mag var., deg NOAA	GPS-GGA Mag var., deg adjust[2]	Constant Heading Error, deg	Gold Creek Q, cfs	Moving bed uncertainty	Calculated moving bed bias	95% Uncer-tainty	Rating
7/9/12	14:23	X110.0C1	113.6	110.0	28,329	0.005	28,894	0.005	28,697	0.006	18.5	18.5	0.0	31900	0.5		1.6	Excellent
7/9/12	15:23	X108.4C1	111.9	108.4	28,296	0.004	<1% correction		28,559	0.009	18.5	21	-2.5	31900	0.5		2.1	Good
7/9/12	16:46	X106.7C1	110.5	106.7	28,825	0.007	29,277	0.008	28,920	0.005	18.5	19	-0.5	31800	0.5		2.0	Good
7/9/12	18:26	X103.0C1	107.1	103.0	28,409	0.012	29,320	0.012	29,148	0.006	18.5	20	-1.5	31600	0.5		2.4	Good
7/10/12	12:59	X98.8C2	102.7	98.8	1,463	0.021	No loop test		1,487	0.016	18.5	15	3.5	26900	0.5		2.9	Good
7/10/12	14:01	X98.8C1	102.7	98.8	22,546	0.023	23,806	0.020	23,377	0.009365213	18.5	18	0.5	26600	0.5		3.4	Good
7/10/12	14:38	X98.8C3	102.7	98.8	1,321	0.018	No loop test		1,341	0.002	18.5	18	0.5	26300	0.5		1.2	Excellent
7/10/12	16:08	X98.0C5	101.4	98.0	20,285	0.006	20,947	0.004	21,192	0.005	18.5	18.5	0.0	25900	0.5		1.6	Excellent
7/11/12	12:32	X95.0C1	98.4	95.0	42,006	0.014	44,895	0.011	45,024	0.018	18.5	16	2.5	22600	0.5		3.2	Good
7/11/12	13:36	X95.0C2	98.4	95.0	1,252	0.016	1,299	0.017	1,287	0.011	18.5	16	2.5	22500	0.5		3.0	Good
7/11/12	16:19	X95.0C4	98.4	95.0	176	0.048	Invalid closure		164	0.064	18.5	18	0.5	22200	1.5	3.0	10.8	Poor
7/11/12	17:48	X94.0C2	97.0	94.0	33,005	0.011	34,604	0.012	34,289	0.007	18.5	18.5	0.0	21800	0.5		2.4	Good
7/11/12	19:06	X94.0C1	97.0	94.0	10,198	0.025	10,513	0.024	10,347	0.014	18.5	18	0.5	21600	0.5		3.9	Good
7/12/12	14:43	X86.9C2	91.0	86.9	41,328	0.015	43,483	0.012	42,843	0.004	18.5	18	0.5	20100	0.5		2.4	Good
7/12/12	15:55	X86.9C1	91.0	86.9	467	0.036	NR - bed v £ 0.04		475	0.012	18.5	13	5.5	20000			1.9	Excellent
7/12/12	16:20	X86.9C1.5	91.0	86.9	507	0.009	No loop test		511	0.011	18.5	18.5	0.0	19900			1.8	Excellent
7/12/12	17:30	X83.0C2	87.1	83.0	28,650	0.010	29,345	0.011	29,359	0.005	18.5	18.5	0.0	19700	0.5		1.6	Excellent
7/12/12	18:30	X83.0C1	87.1	83.0	12,724	0.008	13,191	0.008	12,947	0.009	18.5	18	0.5	19700	0.5		2.0	Good
7/13/12	12:46	X82.0C1	86.3	82.0	4,059	0.012	4,222	0.013	4,238	0.006	18.4	17	1.4	18800	0.5		1.7	Excellent
7/13/12	13:40	X82.0C2	86.3	82.0	36,017	0.008	Lost bottom track		37,658	0.007	18.4	17	1.4	18900	0.5		1.8	Excellent
7/13/12	15:29	X79.0C2	83.0	79.0	12,422	0.005	NR - bed v £ 0.04		12,317	0.005	18.4	18	0.4	18700			1.1	Excellent
7/13/12	16:48	X79.0C1	83.0	79.0	28,394	0.007	29,554	0.006	29,392	0.003	18.4	17	1.4	18600	0.5		1.7	Excellent
8/6/12	16:13	X184.1C1	187.2	184.1	14,707	0.025	No loop test		14,668	0.007	19.2	21	-1.8	19300			3.5	Good
8/6/12	17:05	X183.4C1	186.2	183.4	14,419	0.021	No loop test		14,111	0.017	19.2	24	-4.8	19300			3.0	Good
8/6/12	18:24	X182.2C1	184.9	182.2	14,176	0.011	No loop test		14,239	0.005	19.2	22	-2.8	19100			1.1	Excellent
8/7/12	12:38	X181.7C1	184.4	181.7	14,775	0.018	NR - bed v £ 0.04		14,700	0.006	19.2	20	-0.8	18300			2.7	Good
8/7/12	13:35	X180.3C1	183.3	180.3	14,153	0.023	NR - bed v £ 0.04		14,183	0.001	19.1	22	-2.9	18200			0.6	Excellent
8/7/12	14:44	X178.9C1	181.6	178.9	14,330	0.008	14,705	0.008	14,568	0.005	19.1	21	-1.9	18200	0.5		2.0	Good
8/7/12	15:41	X176.8C1	179.5	176.8	14,222	0.007	<1% correction		14,345	0.003	19.1	24	-4.9	18100	0.5		1.4	Excellent
8/7/12	16:37	X176.1C1	178.5	176.1	14,486	0.010	14,796	0.009	14,799	0.007	19.1	22	-2.9	18000	0.5		1.8	Excellent
8/8/12	12:07	X173.9C1	176.5	173.9	14,559	0.012	NR - bed v £ 0.04		14,469	0.007	19.1	18	1.1	17300			1.9	Excellent
8/8/12	15:16	X167.0C1	170.1	167.0	14,568	0.010	NR - bed v £ 0.04		14,490	0.01	19.0	17	2.0	17200			1.7	Excellent
8/8/12	16:03	X164.5C1	168.1	164.5	14,593	0.004	<1% correction		14,655	0.005	19.0	17	2.0	17300	0.5		1.6	Excellent
8/9/12	15:03	15291500	225.0	223.0	10,938	0.022	11,091	0.022	11,260	0.003	19.5	24	-4.5	17500	0.5		1.4	Excellent
8/10/12	15:03	X150.2C1	153.7	150.2	14,588	0.007	NR - bed v £ 0.04		14,508	0.003	18.9	12	6.9	16800			1.3	Excellent
8/10/12	16:07	X148.7C1	152.1	148.7	15,351	0.028	Invalid closure		15,173	0.003	18.9	15	3.9	16800			3.9	Good
8/10/12	18:03	X144.8C1	148.3	144.8	14,941	0.005	Invalid closure		14,622	0.004	18.8	17	1.8	16600			1.1	Excellent
8/12/12	13:12	X142.3C1	146.6	142.3	17,354	0.010	Invalid closure		16,890	0.009	18.8	20	-1.2	18100			1.7	Excellent
8/12/12	14:58	X140.2C1	143.5	140.2	17,006	0.007	NR - bed v £ 0.04		16,905	0.007	18.8	20	-1.2	18100			1.3	Excellent
8/12/12	16:29	X138.9C1	142.2	138.9	16,798	0.008	Invalid closure		16,508	0.007	18.8	20	-1.2	18100			1.5	Excellent
8/12/12	17:13	X138.5C1	141.9	138.5	16,803	0.005	NR - bed v £ 0.04		16,580	0.009	18.8	20	-1.2	18000			1.1	Excellent
8/13/12	12:54	X136.7C1	140.0	136.7	16,350	0.010	NR - bed v £ 0.04		16,345	0.02	18.7	23	-4.3	17800			1.7	Excellent
8/13/12	13:58	X135.7C1	139.0	135.7	16,449	0.015	NR - bed v £ 0.04		16,242	0.008	18.7	20	-1.3	17700			2.3	Good
8/13/12	14:48	X135.4C1	138.7	135.4	16,344	0.008	Invalid closure		15,936	0.004	18.7	20	-1.3	17700			1.5	Excellent
8/13/12	16:14	X134.3C1	137.6	134.3	16,409	0.002	Invalid closure		15,980	0.005	18.7	19	-0.3	17600			0.7	Excellent

Date	Mid-point time	Site	Project River Mile	Brailey River Mile	ADCP Serial No.	Compass Calibration	Mmt duration, s	No. of Transects	% Top & Bottom Est's	Extrapolation Settings1	% Edge Est's.	Loop Test Results										
												Start time	Duration, s	DMG, ft	Velocity, ft/s		Direction, deg			% Corr	% bad BT	out-back difference
															Bed	Flow	Bed	Flow	Diff			
8/13/12	17:41	X131.8C1	135.0	131.8	3061	off-boat	692	4	21.0	C/N-0.269	0.003	17:26	304	~~31.5~~	~~0.10~~	6.67	~~240.8~~	253.3	~~12.5~~	~~1.55~~	1.97	3.6
8/14/12	13:14	X130.9C1	134.1	130.9	3061	off-boat	764	4	20.7	C/N-0.269	0.027	13:02	302	~~15.2~~	~~0.05~~	5.41	~~286.7~~	255.2	~~328.4~~	~~0.93~~	0.66	3.8
8/14/12	14:05	X130.5C2	133.8	130.5	3061	off-boat	892	4	24.6	C/N-0.249	0.176	13:47	359	~~32.3~~	~~0.09~~	6.27	~~268.3~~	248.1	~~339.8~~	~~1.43~~	0.56	4.2
8/14/12	15:17	X129.4C1	132.6	129.4	3061	off-boat	948	4	27.7	C/N-0.274	0.048	15:05	323	~~112.2~~	~~0.35~~	5.87	~~251.6~~	205.8	~~314.2~~	~~5.92~~	0.00	7.3
8/14/12	17:00	X126.6C1	129.7	126.6	3061	off-boat	840	4	24.4	C/N-0.174	0.030	16:47	340	~~42.8~~	~~0.13~~	5.17	~~237.9~~	228.4	~~350.5~~	~~2.43~~	0.59	2.8
8/15/12	12:50	X124.4C1	128.1	124.4	3061	off-boat	1132	4	30.2	C/N-0.214	0.202	12:32	384	~~105.4~~	~~0.27~~	5.59	~~232.0~~	206.6	~~334.7~~	~~4.90~~	0.26	5.2
8/15/12	13:40	X123.3C1	126.8	123.3	3061	off-boat	728	4	21.2	C/N-0.258	0.073	13:29	310	~~29.4~~	~~0.09~~	5.14	~~218.7~~	208.2	~~349.5~~	~~1.85~~	1.61	4.4
8/15/12	14:27	X120.7C1	124.1	120.7	3061	off-boat	796	4	22.5	C/N-0.224	0.045	14:16	321	11.1	0.03	5.28	47.2	217.3	170.1	NR	1.25	0.2
8/15/12	15:59	X119.2C2	122.6	119.2	3061	off-boat	808	4	22.9	C/N-0.210	0.071	15:47	350	~~1.9~~	~~0.01~~	5.60	~~154.5~~	196.6	~~42.0~~	NR	1.43	1.6
8/15/12	16:26	X119.2C1	122.6	119.2	3061	off-boat	796	4	25.6	C/N-0.176	0.248	16:15	332	~~8.2~~	~~0.02~~	0.65	~~197.7~~	198.2	~~0.5~~	NR	1.20	2.0
8/16/12	12:54	X116.4C1	119.9	116.4	3061	off-boat	828	4	23.3	C/N-0.176	0.093	12:41	369	6.0	0.02	5.94	73.2	214.2	141.0	NR	0.27	1.3
8/16/12	14:15	X113.0C1	116.6	113.0	3061	off-boat	952	4	24.2	C/N-0.217	0.028	13:54	354	18.0	0.05	5.53	6.9	183.0	176.1	0.92	0.56	0.8
8/16/12	16:38	X110.0C1	113.6	110.0	3061	off-boat	976	4	23.8	C/N-0.209	0.057	16:24	415	18.3	0.04	5.15	13.2	192.6	179.4	0.86	0.00	1.2
8/17/12	14:57	X106.7C1	110.5	106.7	3061	off-boat	872	4	23.9	C/N-0.230	0.107	14:44	376	24.9	0.07	5.15	23.0	202.8	179.9	1.29	1.06	3.3
8/17/12	17:36	X104.8C1	108.3	104.8	3061	off-boat	808	4	32.8	C/N-0.167	0.117	17:25	308	33.1	0.11	5.57	357.8	167.7	170.0	1.93	0.00	3.6
8/17/12	18:13	X104.8C2	108.3	104.8	3061	off-boat	780	4	30.1	C/N-0.220	0.491	18:02	339	33.2	0.10	5.32	323.0	147.2	184.2	1.84	2.65	2.6
8/18/12	13:12	X103.0C1	107.1	103.0	3061	off-boat	808	4	23.8	C/N-0.227	0.154	13:00	356	10.4	0.03	5.61	12.4	180.1	167.7	NR	1.69	0.5
8/18/12	14:22	X102.4C1	106.1	102.4	3061	off-boat	952	4	23.7	C/N-0.255	0.128	13:46	386	~~59.2~~	~~0.15~~	5.80	~~237.0~~	232.4	~~355.4~~	~~2.64~~	1.30	4.4
8/18/12	15:23	X101.5C2	105.3	101.5	3061	off-boat	740	4	36.9	C/N-0.237	1.987	15:12	332	~~7.7~~	~~0.02~~	3.70	~~212.4~~	214.6	~~2.2~~	NR	1.20	1.8
8/18/12	16:21	X101.5C1	105.3	101.5	3061	off-boat	856	4	24.7	C/N-0.231	0.312	16:08	323	~~0.7~~	~~0.00~~	6.30	~~135.0~~	208.1	~~73.1~~	NR	0.31	0.2
8/18/12	17:29	X101.0C1	104.7	101.0	3061	off-boat	776	4	37.1	C/N-0.224	1.084	17:17	359	18.3	0.05	2.73	329.1	143.8	174.7	1.87	0.84	2.9
8/18/12	18:07	X101.0C2	104.7	101.0	3061	off-boat	768	4	25.7	C/N-0.229	0.206	17:55	342	19.5	0.06	6.77	349.3	161.8	172.5	0.84	0.00	1.3
8/19/12	12:07	X100.4C3	104.1	100.4	3061	off-boat	876	4	30.2	C/N-0.154	0.403	11:53	365	20.3	0.06	5.20	347.4	161.7	174.3	1.07	0.27	1.5
8/19/12	12:42	X100.4C2	104.1	100.4	3061	off-boat	456	4	35.2	C/N-0.275	23.401	No loop test - small channel. Mean H2O velocity 0.6 ft/s, bed probably not moving										
8/19/12	13:37	X100.4C1	104.1	100.4	3061	off-boat	834	6	31.3	C/N-0.193	3.702	13:24	308	6.3	0.02	6.15	307.2	132.5	185.3	0.00	2.93	1.8
8/19/12	15:40	2RIVC1	--	98.2	3061	off-boat	1700	4	25.4	C/N-0.209	0.001	15:10	641	203.5	0.32	6.39	325.0	181.5	216.5	4.97	1.09	1.9
8/20/12	14:13	X95.0C1	98.4	95.0	3061	off-boat	968	4	23.7	C/N-0.190	0.033	13:59	410	112.0	0.27	6.31	351.1	187.9	196.8	4.33	8.31	3.7
8/20/12	14:40	X95.0C2	98.4	95.0	3061	off-boat	930	6	32.9	C/N-0.170	0.263	No loop test - small channel. Mean H2O velocity 1.8 ft/s, bed probably not moving										
8/20/12	15:41	X95.0C3	98.4	95.0	3061	off-boat	762	6	38.2	P/P-0.249	5.007	No loop test - small channel. Mean H2O velocity 0.8 ft/s, bed probably not moving										
8/20/12	16:42	X94.0C2	97.0	94.0	3061	off-boat	1028	4	24.9	C/N-0.213	0.039	16:28	365	74.9	0.21	6.06	63.5	248.8	185.3	3.39	3.57	0.2
8/20/12	17:25	X94.0C1	97.0	94.0	3061	off-boat	784	4	22.4	C/N-0.167	-0.017	17:14	333	14.2	0.04	4.34	18.6	194.6	176.0	0.98	2.11	1.6
8/21/12	14:12	X87.7C2	91.6	87.7	3061	off-boat	1016	4	24.9	C/N-0.178	0.018	13:55	372	~~171.0~~	~~0.46~~	5.68	~~340.5~~	157.7	177.2	~~8.09~~	1.89	5.4
8/21/12	15:38	X87.7C1	91.6	87.7	3061	off-boat	896	4	27.2	C/N-0.241	0.184	No loop test - small channel. Mean H2O velocity 1.0 ft/s, bed probably not moving										
8/21/12	16:51	X86.9C3	91.0	86.9	3061	off-boat	1308	4	25.3	C/N-0.152	0.015	16:31	417	134.9	0.32	6.17	358.1	187.9	189.8	5.24	1.92	2.8
8/22/12	13:34	X84.6C3	88.4	84.6	3061	off-boat	726	6	24.0	C/N-0.238	0.190	13:23	197	3.1	0.02	6.74	53.8	221.8	168.1	5.24	1.53	0.5
8/22/12	13:54	X84.6C2	88.4	84.6	3061	off-boat	808	8	41.4	C/N-0.221	4.528	No loop test because C3 bed not moving with similar slope and 10X discharge										
8/22/12	15:56	X84.6C1	88.4	84.6	3061	off-boat	780	4	33.2	C/N-0.162	0.263	15:41	302	17.1	0.06	3.49	112.6	307.5	194.8	1.62	1.33	0.7
8/22/12	16:41	X84.6C4	88.4	84.6	3061	off-boat	944	4	25.6	C/N-0.211	0.044	16:21	379	49.2	0.13	7.99	37.5	215.0	177.4	1.63	3.97	2.2
8/22/12	18:01	X81.2C2	85.4	81.2	3061	off-boat	992	4	23.0	C/N-0.184	0.018	17:47	387	130.0	0.34	5.92	296.1	106.6	170.4	5.67	2.07	5.4
8/23/12	14:24	X80.0C1	84.4	80.0	3061	off-boat	788	4	20.1	C/N-0.169	0.103	14:07	327	46.7	0.14	6.43	330.5	152.1	181.6	2.22	2.45	0.3
8/23/12	15:15	X80.0C4	84.4	80.0	3061	off-boat	732	6	28.5	C/N-0.157	0.774	No loop test - small channel. Mean H2O velocity 1.4 ft/s, bed probably not moving										
8/23/12	16:10	X80.0C5	84.4	80.0	3061	off-boat	968	4	37.8	C/N-0.077	0.178	15:58	359	~~34.0~~	~~0.09~~	2.27	~~152.7~~	198.4	~~45.7~~	~~4.16~~	0.56	6.1
8/23/12	17:29	X78.0C1	82.3	78.0	3061	off-boat	848	4	25.5	C/N-0.180	0.034	17:16	330	35.7	0.11	5.69	1.9	153.9	152.1	1.90	1.22	0.2
8/23/12	18:14	X78.0C2	82.3	78.0	3061	off-boat	752	4	23.4	C/N-0.195	0.091	18:03	319	21.2	0.07	4.02	295.3	113.9	178.6	1.65	1.26	2.4
8/24/12	14:28	X76.0C1	80.0	76.0	3061	off-boat	912	4	23.2	C/N-0.190	0.078	14:13	358	69.7	0.19	6.14	356.8	188.9	192.1	3.17	1.68	3.4

Date	Mid-point time	Site	Project River Mile	Brailey River Mile	Bottom Track		Loop Corrected		GPS-GGA				Constant Heading Error, deg	Gold Creek Q, cfs	Moving bed uncertainty	Calculated moving bed bias	95% Uncer-tainty	Rating
					Q, cfs	COV	Q, cfs	COV	Q, cfs	COV	Mag var., deg NOAA	Mag var., deg adjust[2]						
8/13/12	17:41	X131.8C1	135.0	131.8	15,627	0.006	Invalid closure		15,028	0.01	18.7	18	0.7	17400			1.2	Excellent
8/14/12	13:14	X130.9C1	134.1	130.9	16,491	0.009	Invalid closure		16,159	0.018	18.7	17	1.7	17400			1.6	Excellent
8/14/12	14:05	X130.5C2	133.8	130.5	16,275	0.008	Invalid closure		15,758	0.011	18.7	17	1.7	17300			1.5	Excellent
8/14/12	15:17	X129.4C1	132.6	129.4	16,039	0.013	Invalid closure		14,925	0.015	18.7	20	-1.3	17300			2.1	Good
8/14/12	17:00	X126.6C1	129.7	126.6	16,330	0.005	Invalid closure		15,829	0.002	18.7	20	-1.3	17300			1.1	Excellent
8/15/12	12:50	X124.4C1	128.1	124.4	15,926	0.009	Invalid closure		15,155	0.006	18.6	18	0.6	17600			1.6	Excellent
8/15/12	13:40	X123.3C1	126.8	123.3	16,078	0.011	Invalid closure		15,709	0.006	18.6	18	0.6	17600			1.8	Excellent
8/15/12	14:27	X120.7C1	124.1	120.7	16,161	0.006	NR - bed v £ 0.04		16,114	0.01	18.6	16	2.6	17600			1.2	Excellent
8/15/12	15:59	X119.2C2	122.6	119.2	16,110	0.006	NR - bed v £ 0.04		15,895	0.006	18.6	18	0.6	17600			1.2	Excellent
8/15/12	16:26	X119.2C1	122.6	119.2	177	0.028	NR - bed v £ 0.04		168	0.026	18.6	18	0.6	17400			3.9	Good
8/16/12	12:54	X116.4C1	119.9	116.4	16,005	0.008	NR - bed v £ 0.04		15,827	0.005	18.6	19	-0.4	17600			1.5	Excellent
8/16/12	14:15	X113.0C1	116.6	113.0	16,129	0.006	<1% correction		16,136	0.004	18.5	20	-1.5	17600	0.5		1.5	Excellent
8/16/12	16:38	X110.0C1	113.6	110.0	16,291	0.013	NR - bed v £ 0.04		16,311	0.003	18.5	19	-0.5	17500			0.9	Excellent
8/17/12	14:57	X106.7C1	110.5	106.7	14,997	0.004	15,239	0.005	15,254	0.006	18.5	20	-1.5	18000	0.5		1.7	Excellent
8/17/12	17:36	X104.8C1	108.3	104.8	9,066	0.019	9,260	0.019	9,119	0.005	18.5	19	-0.5	17900	0.5		3.3	Good
8/17/12	18:13	X104.8C2	108.3	104.8	6,993	0.005	7,134	0.004	7,130	0.017	18.5	17	1.5	17800	0.5		1.5	Excellent
8/18/12	13:12	X103.0C1	107.1	103.0	15,508	0.001	NR - bed v £ 0.04		GPS ship tracks incorrect					16300			0.6	Excellent
8/18/12	14:22	X102.4C1	106.1	102.4	15,278	0.005	Invalid closure		GPS ship tracks incorrect					16100			1.1	Excellent
8/18/12	15:23	X101.5C2	105.3	101.5	2,369	0.008	NR - bed v £ 0.04		2,333	0.006	18.5	22	-3.5	16000			1.5	Excellent
8/18/12	16:21	X101.5C1	105.3	101.5	12,993	0.008	NR - bed v £ 0.04		12,854	0.006	18.5	22	-3.5	15900			1.5	Excellent
8/18/12	17:29	X101.0C1	104.7	101.0	2,073	0.008	2,115	0.008	2,098	0.007	18.5	21	-2.5	16000			1.3	Excellent
8/18/12	18:07	X101.0C2	104.7	101.0	13,259	0.006	<1% correction		13,279	0.004	18.5	23	-4.5	16000	0.5		1.5	Excellent
8/19/12	12:07	X100.4C3	104.1	100.4	11,394	0.010	11,527	0.009	11,442	0.005	18.5	21	-2.5	16400			1.6	Excellent
8/19/12	12:42	X100.4C2	104.1	100.4	48	0.028	No loop test		48	0.04	18.5	22	-3.5	16500			5.3	Fair
8/19/12	13:37	X100.4C1	104.1	100.4	3,754	0.010	NR - bed v £ 0.04		3,770	0.006	18.5	21	-2.5	16400			1.1	Excellent
8/19/12	15:40	2RIVC1	--	98.2	30,581	0.009	32,450	0.011	34,297	0.031670209	18.5	20	-1.5	16500	0.5		4.8	Good
8/20/12	14:13	X95.0C1	98.4	95.0	36,913	0.029	38,872	0.026	39,546	0.01	18.5	21	-2.5	16600	0.5		2.2	Good
8/20/12	14:40	X95.0C2	98.4	95.0	961	0.021	No loop test		979	0.013	18.5	22	-3.5	16700			1.8	Excellent
8/20/12	15:41	X95.0C3	98.4	95.0	96	0.019	No loop test		98	0.029	18.5	19	-0.5	17000			3.4	Good
8/20/12	16:42	X94.0C2	97.0	94.0	30,338	0.013	31,621	0.014	31,722	0.004	18.5	20	-1.5	17400	0.5		1.5	Excellent
8/20/12	17:25	X94.0C1	97.0	94.0	8,473	0.009	NR - bed v £ 0.04		8,539	0.004	18.5	21	-2.5	17600	0.5		1.5	Excellent
8/21/12	14:12	X87.7C2	91.6	87.7	42,175	0.006	bad out-back Ð		45,689	0.002	18.4	20	-1.6	18500	0.5		1.2	Excellent
8/21/12	15:38	X87.7C1	91.6	87.7	608	0.013	No loop test		641	0.01	18.4	21	-2.6	18500			1.7	Excellent
8/21/12	16:51	X86.9C3	91.0	86.9	41,921	0.007	45,216	0.013	45,557	0.005	18.4	21	-2.6	18500	0.5		1.6	Excellent
8/22/12	13:34	X84.6C3	88.4	84.6	4,057	0.011	NR - bed v £ 0.04		4,041	0.007	18.4	21	-2.6	18200			1.6	Excellent
8/22/12	13:54	X84.6C2	88.4	84.6	468	0.021	No loop test		470	0.016	18.4	20	-1.6	18200			1.8	Excellent
8/22/12	15:56	X84.6C1	88.4	84.6	2,818	0.017	2,870	0.017	2,860	0.009	18.4	17	1.4	17900	0.5		2.1	Good
8/22/12	16:41	X84.6C4	88.4	84.6	33,470	0.013	34,203	0.011	34,310	0.005	18.4	20	-1.6	17900	0.5		1.6	Excellent
8/22/12	18:01	X81.2C2	85.4	81.2	40,468	0.004	43,318	0.005	42,181	0.009	18.4	16	2.4	17600	0.5		1.6	Excellent
8/23/12	14:24	X80.0C1	84.4	80.0	31,997	0.007	32,864	0.008	32,533	0.009	18.4	22	-3.6	16100	0.5		2.0	Good
8/23/12	15:15	X80.0C4	84.4	80.0	712	0.038	No loop test		706	0.026	18.4	21	-2.6	16100			4.3	Good
8/23/12	16:10	X80.0C5	84.4	80.0	3,356	0.037	Invalid closure		3,187	0.017	18.4	18	0.4	15900	1.5	2.2	8.7	Poor
8/23/12	17:29	X78.0C1	82.3	78.0	25,660	0.008	26,202	0.008	25,852	0.003	18.4	20	-1.6	15800	0.5		2.0	Good
8/23/12	18:14	X78.0C2	82.3	78.0	11,520	0.007	11,745	0.007	11,671	0.005	18.4	20	-1.6	15700	0.5		1.8	Excellent
8/24/12	14:28	X76.0C1	80.0	76.0	34,223	0.007	35,401	0.007	35,490	0.007	18.4	20	-1.6	16200	0.5		1.8	Excellent

Date	Mid-point time	Site	Project River Mile	Brailey River Mile	ADCP Serial No.	Compass Calibration	Mmt duration, s	No. of Transects	% Top & Bottom Est's	Extrapolation Settings1	% Edge Est's.	Loop Test Results: Start time	Duration, s	DMG, ft	Velocity, ft/s: Bed	Velocity, ft/s: Flow	Direction, deg: Bed	Direction, deg: Flow	Direction, deg: Diff	% Corr	% bad BT	out-back difference
8/24/12	15:45	X76.0C5	80.0	76	3061	off-boat	732	4	20.7	C/N-0.124	-0.026	15:35	240	6.7	0.03	0.93	10.2	201.2	191.1	NR	0.84	1.9
9/14/12	17:05	X176.8C1	179.5	176.8	3061	off-boat	740	4	24.9	C/N-0.231	0.190	16:54	303	9.4	0.03	5.47	41.5	230.6	189.1	NR	0.66	1.4
9/14/12	17:47	X176.2C1	178.5*	176.2	3061	off-boat	836	4	26.2	C/N-0.246	0.180	17:35	332	18.6	0.06	5.08	11.0	185.2	174.1	1.10	1.81	2.8
9/15/12	13:17	X184.1C1	187.2	184.1	3061	off-boat	788	4	25.1	C/N-0.230	0.157	13:06	302	~~4.2~~	~~0.01~~	6.07	~~307.1~~	272.7	~~325.6~~	NR	2.65	0.3
9/15/12	14:05	X183.4C1	186.2	183.4	3061	off-boat	864	4	24.0	C/N-0.248	0.088	13:52	375	~~2.7~~	~~0.01~~	3.72	~~221.8~~	268.8	~~47.0~~	NR	1.33	3.2
9/15/12	14:57	X182.2C1	184.9	182.2	3061	off-boat	864	4	28.9	C/N-0.219	0.115	14:45	337	~~9.7~~	~~0.03~~	4.91	~~290.4~~	262.6	~~332.2~~	NR	0.59	1.4
9/15/12	15:52	X181.7C1	184.4	181.7	3061	off-boat	812	4	25.0	C/N-0.230	0.124	15:41	314	~~6.1~~	~~0.02~~	5.48	~~183.5~~	266.8	~~83.3~~	NR	2.23	3.8
9/15/12	16:41	X180.3C1	183.3	180.3	3061	off-boat	888	4	25.7	C/N-0.188	0.058	16:28	368	~~1.8~~	~~0.00~~	3.54	~~138.4~~	251.7	~~113.3~~	NR	1.09	2.2
9/15/12	17:55	X178.9C1	181.6	178.9	3061	off-boat	860	4	25.3	C/N-0.233	0.063	17:43	328	24.6	0.08	4.26	352.9	173.3	180.4	1.76	0.61	0.3
9/16/12	14:50	X173.9C1	176.5	173.9	2837	off-boat	820	4	26.1	C/N-0.232	0.104	14:39	317	~~12.9~~	~~0.04~~	5.22	~~305.2~~	294.7	~~349.6~~	~~0.78~~	0.63	2.2
9/16/12	16:29	X170.0C1	173.1	170	2837	off-boat	800	4	26.1	C/N-0.202	0.302	16:17	318	~~7.7~~	~~0.02~~	6.39	~~307.9~~	284.2	~~336.3~~	~~0.78~~	0.94	1.6
9/16/12	17:33	X167.0C1	170.1	167	2837	off-boat	840	4	24.3	C/N-0.232	0.149	17:21	327	~~8.5~~	~~0.03~~	5.13	~~294.6~~	282.9	~~348.3~~	~~0.78~~	0.92	2.3
9/17/12	15:19	X164.5C1	168.1	164.5	2837	off-boat	856	4	26.4	C/N-0.205	0.062	15:08	310	22.0	0.07	6.40	164.1	359.1	195.0	1.11	2.26	0.6
9/29/12	15:20	X148.7C1	152.1	148.7	2837	off-boat	792	4	22.2	C/N-0.218	0.045	15:05	343	~~6.9~~	~~0.02~~	6.47	~~209.7~~	283.8	~~74.1~~	NR	2.05	3.0
9/29/12	16:51	X142.3C1	145.7	142.3	2837	off-boat	784	4	24.9	C/N-0.223	0.031	16:38	307	~~76.9~~	~~0.25~~	6.43	~~230.1~~	231.0	~~0.9~~	~~3.90~~	1.63	9.9
9/29/12	17:45	X138.9C1	142.2	138.9	2837	off-boat	884	4	27.1	C/N-0.209	0.072	17:31	400	~~74.3~~	~~0.19~~	6.50	~~252.9~~	247.7	~~354.9~~	~~2.86~~	1.75	6.3
9/30/12	13:56	X136.7C1	140.0	136.7	2837	off-boat	752	4	23.0	C/N-0.221	0.033	13:39	307	2.9	0.01	7.10	111.1	258.0	146.9	NR	1.95	1.0
9/30/12	15:00	X134.3C1	137.6	134.3	2837	off-boat	924	4	25.9	C/N-0.230	0.029	14:44	339	~~31.7~~	~~0.09~~	5.73	~~203.8~~	212.0	~~8.3~~	~~1.63~~	0.59	2.6
10/1/12	13:40	X131.2C1	134.3	131.2	2837	off-boat	936	4	24.9	C/N-0.217	0.054	13:25	364	~~65.9~~	~~0.18~~	7.40	~~258.3~~	266.9	~~8.6~~	~~2.45~~	1.93	6.6
10/1/12	16:16	X126.6C1	129.7	126.6	2837	off-boat	812	4	23.1	C/N-0.204	0.014	16:00	331	~~110.9~~	~~0.34~~	4.58	~~230.66~~	228	~~8.57~~	~~7.32~~	1.82	9.0
10/1/12	17:02	X123.3C1	126.8	123.3	2837	off-boat	776	4	20.8	C/N-0.258	0.073	16:51	311	~~74.0~~	~~0.24~~	4.62	~~205.5~~	207.5	~~1.9~~	~~7.32~~	2.89	11.0
10/1/12	17:42	X120.7C1	124.1	120.7	2837	off-boat	744	4	24.1	C/N-0.258	0.016	17:31	318	~~48.2~~	~~0.15~~	4.45	~~219.1~~	218.7	~~359.5~~	~~3.41~~	4.42	10.1
10/3/12	14:47	X116.4C1	119.9	116.4	2837	off-boat	768	4	24.0	C/N-0.194	0.090	Loop test module wont execute - recorder issue										
10/3/12	15:53	X113.0C1	116.6	113.0	2837	off-boat	760	4	23.8	C/N-0.226	0.147	Loop test module wont execute - recorder issue										
10/3/12	16:41	X110.0C1	113.6	110.0	2837	off-boat	868	4	19.0	C/N-0.212	0.044	Loop test module wont execute - recorder issue										
10/3/12	17:33	X106.7C1	110.5	106.7	2837	off-boat	872	4	24.9	C/N-0.216	0.148	Loop test module wont execute - recorder issue										
10/4/12	14:10	X103.0C1	107.1	103.0	2837	off-boat	776	4	23.9	C/N-0.242	0.184	14:20	320	13.6	0.04	5.11	Loop transect with upstream DMG					
10/4/12	15:58	X99.6C3	103.5	99.6	2837	off-boat	804	4	26.1	C/N-0.218	0.090	15:41	328	8.6	0.03	5.23	Loop transect with upstream DMG					
10/4/12	16:48	X99.6C2	103.5	99.6	2837	off-boat	904	4	33.5	C/N-0.213	0.401	16:33	368	27.9	0.08	3.11	Loop transect with upstream DMG					
10/4/12	17:41	X99.6C1	103.5	99.6	2837	off-boat	780	4	36	C/N-0.170	0.504	17:29	327	14.0	0.04	3.56	Loop transect with upstream DMG					
10/5/12	14:06	X95.0C1	98.4	95.0	2837	off-boat	956	4	23.2	C/N-0.193	0.003	13:54	326	80.2	0.25	5.09	359.8	186.4	186.6	4.83	4.60	3.3
10/5/12	14:36	X95.0C2	98.4	95.0	2837	off-boat	822	6	24.9	C/N-0.120	0.051	No loop test - small channel. Mean H2O velocity 1.1 ft/s, bed probably not moving										
10/5/12	15:10	X95.0C3&4	98.4	95.0	2837	off-boat	666	6	44.9	C/N-0.174	0.234	No loop test - small channel. Mean H2O velocity 3.4 ft/s, bed probably not moving										
10/5/12	15:24	X95.0C4	98.4	95.0	2837	off-boat	436	4	30.1	P/P-0.210	0.569	No loop test - small channel. Mean H2O velocity 0.85 ft/s, bed probably not moving										

Date	Mid-point time	Site	Project River Mile	Brailey River Mile	Bottom Track		Loop Corrected		GPS-GGA				Constant Heading Error, deg	Gold Creek Q, cfs	Moving bed uncertainty	Calculated moving bed bias	95% Uncer-tainty	Rating
					Q, cfs	COV	Q, cfs	COV	Q, cfs	COV	Mag var., deg NOAA	adjust[2]						
8/24/12	15:45	X76.0C5	80.0	76.0	1,005	0.037	NR - bed v £ 0.04		1,013	0.027	18.4	20	-1.6	16200	0.5		4.2	Good
9/14/12	17:05	X176.8C1	179.5	176.8	8,297	0.008	NR - bed v £ 0.04		8,361	0.01	19.1	24	-4.9	10100	0.5		2.2	Good
9/14/12	17:47	X176.2C1	178.5*	176.2	8,628	0.008	8,738	0.008	8,670	0.013	19.1	22	-2.9	10000	0.5		2.0	Good
9/15/12	13:17	X184.1C1	187.2	184.1	7,838	0.018	NR - bed v £ 0.04		7,774	0.009	19.2	22	-2.8	10800			2.7	Good
9/15/12	14:05	X183.4C1	186.2	183.4	7,621	0.009	NR - bed v £ 0.04		7,630	0.003	19.2	20	-0.8	10800			0.9	Excellent
9/15/12	14:57	X182.2C1	184.9	182.2	7,692	0.007	NR - bed v £ 0.04		7,714	0.003	19.2	19.2	0.0	11000			0.9	Excellent
9/15/12	15:52	X181.7C1	184.4	181.7	8,353	0.022	NR - bed v £ 0.04		8,352	0.005	19.2	20	-0.8	11100			3.1	Good
9/15/12	16:41	X180.3C1	183.3	180.3	8,310	0.010	NR - bed v £ 0.04		8,306	0.008	19.1	20	-0.9	11300			1.7	Excellent
9/15/12	17:55	X178.9C1	181.6	178.9	8,508	0.015	8,689	0.016	8,584	0.007	19.1	21	-1.9	11500	0.5		2.9	Good
9/16/12	14:50	X173.9C1	176.5	173.9	10,768	0.011	NR - bed v £ 0.04		10,638	0.006	19.1	16	3.1	16500			1.8	Excellent
9/16/12	16:29	X170.0C1	173.1	170.0	11,082	0.008	NR - bed v £ 0.04		11,045	0.008	19.1	15	4.1	17200			1.5	Excellent
9/16/12	17:33	X167.0C1	170.1	167.0	11,137	0.012	NR - bed v £ 0.04		10,921	0.007	19.0	15	4.0	17600			1.9	Excellent
9/17/12	15:19	X164.5C1	168.1	164.5	14,445	0.008	14,619	0.008	14,433	0.006	19.0	16	3.0	20200	0.5		2.0	Good
9/29/12	15:20	X148.7C1	152.1	148.7	18,488	0.014	NR - bed v £ 0.04		18,064	0.02	18.9	9	9.9	20000			2.2	Good
9/29/12	16:51	X142.3C1	145.7	142.3	18,131	0.018	Invalid closure		17,268	0.006	18.8	15	3.8	19800			2.7	Good
9/29/12	17:45	X138.9C1	142.2	138.9	18,301	0.004	Invalid closure		17,580	0.007	18.8	12	6.8	19800			1.0	Excellent
9/30/12	13:56	X136.7C1	140.0	136.7	17,619	0.018	NR - bed v £ 0.04		17,541	0.005	18.8	23	-4.2	17800			2.7	Good
9/30/12	15:00	X134.3C1	137.6	134.3	17,382	0.005	Invalid closure		17,033	0.006	18.7	16	2.7	17700			1.1	Excellent
10/1/12	13:40	X131.2C1	134.3	131.2	15,568	0.008	Invalid closure		15,214	0.011	18.7	12	6.7	15500			1.5	Excellent
10/1/12	16:16	X126.6C1	129.7	126.6	15,731	0.008	Invalid closure		14,340	0.003	18.8	19	-0.2	15400			1.5	Excellent
10/1/12	17:02	X123.3C1	126.8	123.3	15,582	0.007	Invalid closure		14,676	0.006	18.6	21	-2.4	15400			1.3	Excellent
10/1/12	17:42	X120.7C1	124.1	120.7	15,582	0.016	Invalid closure		14,928	0.01	18.6	21	-2.4	15300			2.4	Good
10/3/12	14:47	X116.4C1	119.9	116.4	13,927	0.006	No loop test		13,998	0.004	18.6	18.6	0.0	13500	0.5		1.5	Excellent
10/3/12	15:53	X113.0C1	116.6	113.0	14,178	0.009	No loop test		14,323	0.001	18.5	18.5	0.0	13400	0.5		1.1	Excellent
10/3/12	16:41	X110.0C1	113.6	110.0	13,418	0.006	No loop test		13,476	0.004	18.5	18.5	0.0	13400	0.5		1.5	Excellent
10/3/12	17:33	X106.7C1	110.5	106.7	14,053	0.006	No loop test		14,172	0.004	18.5	18	0.5	13400	0.5		1.5	Excellent
10/4/12	14:10	X103.0C1	107.1	103.0	14,532	0.007	NR - bed v £ 0.04		14,558	0.003	18.5	18	0.5	13700			0.9	Excellent
10/4/12	15:58	X99.6C3	--	99.6	7,012	0.013	NR - bed v £ 0.04		7,033	0.009	18.5	18	0.5	13700			1.6	Excellent
10/4/12	16:48	X99.6C2	--	99.6	4,454	0.011	No loop test		4,521	0.011	18.5	18	0.5	13600	0.5		2.3	Good
10/4/12	17:41	X99.6C1	--	99.6	3001.685	0.009	No loop test		3,021	0.009	19	18	0.5	13600			1.6	Excellent
10/5/12	14:06	X95.0C1	98.4	95.0	34,952	0.007	37,161	0.007	36,770	0.005	18.5	21	-2.5	13800	0.5		1.8	Excellent
10/5/12	14:36	X95.0C2	98.4	95.0	858	0.015	No loop test		876	0.025	18.5	20	-1.5	13800	0.5		3.5	Good
10/5/12	15:10	X95.0C3&4	98.4	95.0	808	0.021	No loop test		807	0.018	18.5	24	-5.5	13900			2.6	Good
10/5/12	15:24	X95.0C4	98.4	95.0	207	0.015	No loop test		221	0.028	18.5	19	-0.5	13900	0.5		4.4	Good

Notes:

1 Yellow: values outside accepted ranges
2 Blue: related fields
3 Green: recommended value
4 P/P Extrap recommends a power fit for top and bottom; a 0.167 exponent results in <1% error (no correction recommended).
5 C/P User specified a constant fit for the top and power fit for the bottom, using the exponent shown.
6 * Not valid
7 If moving bed suspected, assumed equal to C2 channel

Table A3-3. Estimated Moving Bed Corrections.

Date	Mid-point time	Site	Project River Mile	Brailey River Mile	Loop Test Results: Start time	Duration, s	DMG, ft	Velocity, ft/s: Bed	Velocity, ft/s: Flow	Direction, deg: Bed	Direction, deg: Flow	Direction, deg: Diff	% Corr	% bad BT	out-back difference	measured bed v see note to right	inter-polated bed v	calculated % correction
6/16/12	18:35	X176.1C1	178.5	176.1	No loop test due to diving of ADCP in standing waves												0.08	1.3
6/17/12	16:30	X184.1C1	187.2	184.1	No loop test due to diving of ADCP in standing waves											none		
6/18/12	14:13	X183.4C1	186.2	183.4	13:55	308	35.8	0.12	7.17	75	268	193.05	1.62	11.73	2.5	0.12		
6/18/12	16:10	X182.8C1	185.5	182.8	15:54	312	80.1	0.26	6.83	74	269	194.82	3.76	4.18	6.3	0.26		
6/19/12	13:54	X182.6C2	185.2	182.6	13:40	307	86.7		8.41	12	275	263.59	3.36	44.44	4.9	bad	0.09	1.3
6/19/12	15:49	X182.2C1	184.9	182.2	15:02	317	59.0		7.57	111	263	152.03	2.46	30.7	17.3	bad	0.07	1.1
6/19/12	16:51	X181.7C1	184.4	181.7	16:30	262	99.6		8.19	126	281	154.98	4.64	16.48	16.5	bad	0.05	0.9
6/20/12	13:19	X180.3C1	183.3	180.3	13:08	252	32.6		7.81	228	253	25.35	1.66	8.76	10.8	bad	0.00	0.2
6/20/12	16:58	X179.8C2	182.9	179.8	16:46	268	25.0	0.09	8.36	104	275	170.18	1.12	9.36	3.8	0.09		
6/20/12	17:56	X178.9C1	181.6	178.9	17:43	296	66.9	0.23	7.52	352	182	189.84	3	2.71	0.2	0.23		
6/21/12	12:28	X176.8C1	179.5	176.8	12:17	291	18.1		8.41	216	231	15.46	0.74	9.31	12.8	bad	0.08	1.3
6/21/12	14:40	X173.9C1	178.5	173.9	14:21	323	25.7	0.08	8.07	80	296	216	0.98	7.74	2.2	0.08		
6/21/12	16:12	X172.0C1	174.9	172.0	15:49	340	35.9	0.11	8.35	99	275	175.44	1.26	5.9	2.6	0.11		
6/21/12	17:39	X170.0C1	173.1	170.0	17:18	462	77.2	0.17	8.13	96	280	183.71	2.05	4.12	3.4	0.17		
6/22/12	12:56	X167.0C1	170.1	167.0	12:34	332	21.0	0.06	8.3	123	282	158.91	0.76	3.93	1.7	0.06		
6/22/12	14:33	X164.5C1	168.1	164.5	14:08	362	112.3	0.31	8.19	184	359	535.08	3.79	3.6	8.6	0.31		
6/25/12	14:00	X147.6C1	151.1	147.6	13:48	260	13.1	0.05	8.35	135	283	147.84	0.6	5.79	3.1	0.05		
6/25/12	17:15	X150.2C1	153.7	150.2	16:55	303	42.4	0.14	10.23	107	307	200.06	1.37	11.26	1.2	0.14		
6/26/12	13:43	X149.5C1	152.9	149.5	13:26	335	77.7	0.23	7.47	133	314	181.03	3.11	4.49	4.6	0.23		
6/26/12	15:38	X148.7C1	152.1	148.7	15:20	259	4.6	0.02	8.51	348	282	294.44	NR	9.69	0.9	0.04		
6/26/12	18:24	X144.8C1	148.3	144.8	17:45	216	38.5	0.18	8.56	116	269	152.85	2.08	8.37	9.8	0.18		
6/27/12	12:04	X143.2C2	146.6	143.2	10:22	222	57.5		8.96	60	244	183.77	2.89	4.05	3.5	bad	0.16	2.4
6/27/12	13:51	X142.3C1	145.7	142.3	13:35	234	53.9		8.18	240	233	353.44	2.82	6.01	11.7	bad	0.15	2.2
6/27/12	14:40	X142.1C1	145.5	142.1	14:16	298	135.2		8.5	237	238	0.35	5.34	9.73	18.3	bad	0.15	2.2
6/27/12	17:23	X141.5C2	144.9	141.5	17:13	224	170.7		8.14	231	227	355.94	9.36	11.66	27.8	bad	0.14	2.1
6/27/12	18:29	X140.8C2	144.3	140.8	18:17	291	159.9		8.67	209	208	359.12	6.34	20.96	324	bad	0.14	2.0
6/28/12	12:17	X140.2C1	143.5	140.2	12:04	271	34.0	0.13	7.93	34	219	185.19	1.58	4.8	0.5	0.13		
6/28/12	13:20	X139.4C1	143.0	139.4	13:01	433	16.6	0.04	7.29	330	259	71.17	0	9.47	4.1	0.04		
6/28/12	15:15	X138.9C1	142.2	138.9	15:02	290	4.9	0.02	7.85	134	248	113.80		1.72	0.9	0.04		
6/28/12	16:27	X138.5C1	141.9	138.5	16:16	254	20.1	0.08	7.68	51	232	181.79	1.03	2.76	1.7	0.08		
6/28/12	17:41	X138.2C1	141.7	138.2	17:21	381	9.4	0.02	8.12	48	224	175.46		2.11	0.1	0.04		
6/29/12	14:48	X136.7C1	140.0	136.7	14:28	231	16.1	0.07	9.6	56	256	200.39	0.73	4.33	0.7	0.07		
6/29/12	16:21	X136.4C1	139.8	136.4	16:03	287	7.2	0.02	8.14	145	269	123.69	0.73	5.23	2	0.04		
6/30/12	13:56	X135.7C1	139.0	135.7	13:39	250	17.1		7.67	243	195	311.35	0.89	2.8	2.7	bad	0.04	
6/30/12	14:51	X135.4C1	138.7	135.4	14:38	243	25.7		7.15	173	193	20.39	1.48	1.65	3.2	bad	0.04	
6/30/12	17:13	X134.7C2	138.1	134.7	16:57	263	9.0	0.03	7.96	201	200	358.57		1.14	3.5	0.04		
6/30/12	18:13	X134.3C1	137.6	134.3	17:57	307	34.8		7.07	203	214	10.99	1.6	0.33	3.7	bad	0.06	0.9
7/1/12	13:35	X133.3C1	136.7	133.3	13:10	391	151.6		6.38	221	211	349.86	6.07	10.74	12	bad	0.09	1.4
7/1/12	16:57	X132.9C1	136.2	132.9	16:48	192	20.0	0.1	7.11	30	208	178.60	1.46	2.08	1.1	0.10		
7/1/12	18:17	X131.8C1	135.0	131.8	18:02	274	11.2	0.04	7.11	70	252	181.69	0.57	2.55	0.6	0.04		
7/2/12	12:16	X131.2C1	134.3	131.2	12:03	275	5.8	0.02	7.37	161	269	108.34	NR	0.73	1.1	0.04		
7/2/12	13:18	X130.9C1	134.1	130.9	13:08	222	2.9	0.01	7.08	281	253	332.17		3.6	0.5	0.04		
7/2/12	14:30	X130.5C2	133.8	130.5	14:00	198	20.2		7.43	262	252	350.39	1.37	1.01	2.6	bad	0.04	
7/2/12	16:22	X130.0C2	133.3	130.0	No loop test due to a wide, shallow bar that required walking											none	0.04	
7/2/12	17:57	X129.4C1	132.6	129.4	17:43	336	8.6	0.03	6.19	237.02	212.89	335.87	NR	1.49	2.1	0.04		
7/3/12	14:31	X128.1C1	131.4	128.1	No loop test due to fast shallows requiring 2 people to walk the boat											none	0.05	0.8
7/3/12	17:33	X126.6C1	129.7	126.6	17:17	304	18.4	0.06	6.63	30	228	198.07	0.91	1.97	0.5	0.06		
7/4/12	15:40	X124.4C1	128.1	124.4	16:07	338	40.6		5.66	357	209	211.77	2.12	7.1*	0.3	bad	0.10	1.5
7/4/12	17:22	X123.3C1	126.8	123.3	17:10	294	36.6	0.12	6.78	13	208	194.80	1.83	1.36	2.5	0.12		
7/5/12	13:51	X122.6C2	126.1	122.6	13:41	249	64.9	0.26	7.07	16	205	188.84	3.69	3.21	5.0	0.26		
7/5/12	16:06	X121.8C2	125.4	121.8	15:48	302	74.1	0.25	6.86	22	206	184.12	3.57	2.98	6.5	0.25		
7/5/12	18:11	X120.7C1	124.1	120.7	17:55	263	53.3	0.2	6.96	36	219	183.51	2.91	2.28	3.3	0.20		
7/6/12	11:47	X120.3C1	123.7	120.3	11:29	219	99.5		5.48	18	203	185.11	8.29	0.91	9.3	bad	0.19	2.7
7/6/12	14:23	X119.3C1	122.7	119.3	14:10	324	47.9	0.15	5.68	12	208	195.57	2.6	0.93	2.1	0.15		
7/6/12	15:12	X119.2C2	122.6	119.2	15:01	233	28.2	0.12	6.75	11	196	184.21	1.79	1.29	1.6	0.12		
7/6/12	17:55	X117.2C1	120.7	117.2	17:44	217	19.0	0.09	6.81	19	203	184.12	1.28	1.84	3.0	0.09		
7/7/12	12:19	X116.4C1	119.9	116.4	12:03	238	7.9	0.03	6.5	173	216	42.14	NR	0.4	0.8	0.04		
7/7/12	13:09	X115.0C2	118.4	115.0	12:58	249	7.0	0.03	6.6	234	184	310.12	NR	1.61	1.5	0.04		
7/7/12	16:40	X114.0C2	117.4	114.0	16:25	228	13.1		7.24	253	181	287.68	0.8	1.8	1.9	bad	0.04	0.7
7/7/12	17:36	X113.0C1	116.6	113.0	17:20	379	15.1	0.04	5.97	173	182	9.81	0.67	1.06	1.6	0.04		
7/8/12	12:42	X112.7C1	116.3	112.7	12:26	248	15.9	0.06	6.38	25	180	155.73	1.01	1.61	1.4	0.06		
7/8/12	14:29	X112.2C1	115.7	112.2	14:18	266	34.1	0.13	6.86	7	174	167.06	1.87	0.38	0.7	0.13		
7/8/12	15:45	X111.8C2	115.4	111.8	15:32	253	42.9	0.17	7.21	354	168	173.99	2.35	5.14	3.0	0.17		
7/8/12	18:57	X110.9C2	114.4	110.9	18:43	216	18.4	0.09	7.89	320	132	171.11	1.08	0.46	1.3	0.09		
7/9/12	14:23	X110.0C1	113.6	110.0	14:10	267	29.0	0.11	6.77	354	192	198.16	1.6	1.5	1.7	0.11		
7/9/12	15:23	X108.4C1	111.9	108.4	15:09	290	15.9	0.05	6.81	348	203	215.68	0.8	1.03	0.1	0.05		
7/9/12	16:46	X106.7C1	110.5	106.7	16:11	323	26.3	0.08	6.92	17	201	183.11	1.18	3.41	1.3	0.08		
7/9/12	18:26	X103.0C1	107.1	103.0	18:10	245	43.3	0.18	7.32	0	184	543.39	2.41	2.04	1.8	0.18		
7/10/12	14:01	X98.8C1	102.7	98.8	13:48	275	77.8	0.28	6.25	47	201	154.69	4.53	14.55	4.5	0.28		

Date	Mid-point time	Site	Project River Mile	Brailey River Mile	Loop Test Results											measured	inter-	calculated
					Start time	Duration, s	DMG, ft	Velocity, ft/s		Direction, deg			% Corr	% bad	out-back	bed v	polated	%
								Bed	Flow	Bed	Flow	Diff		BT	difference	see note to right	bed v	correction
7/10/12	16:08	X98.0C5	101.4	98.0	15:44	203	36.5	0.18	6.36	11	202	190.89	2.83	4.43	2.2	0.18		
7/11/12	12:32	X95.0C1	98.4	95.0	12:12	284	103.8	0.37	6.77	354	184	189.50	5.4	6.71	1.8	0.37		
7/11/12	17:48	X94.0C2	97.0	94.0	17:25	339	89.4	0.26	6.79	39	245	205.70	3.88	2.1	5.5	0.26		
7/12/12	14:43	X86.9C2	91.0	86.9	14:20	291	58.7	0.2	5.93	7	193	185.45	3.4	3.1	1.0	0.20		
7/12/12	17:30	X83.0C2	87.1	83.0	17:14	311	43.3	0.14	6.76	358	181	183.66	2.06	8.4	2.9	0.14		
7/13/12	13:40	X82.0C2	86.3	82.0	13:22	390	73.7		6.57	335	150	175.93	2.88	8.4*	2.7	bad	0.16	2.3
7/13/12	16:48	X79.0C1	83.0	79.0	16:32	296	64.9	0.22	6.16	328	140	171.59	3.56	3.4	3.6	0.22		
8/6/12	16:13	X184.1C1	187.2	184.1	No compass calibration - Bluetooth failure.											none	0.04	
8/6/12	17:05	X183.4C1	186.2	183.4	No compass calibration - Bluetooth failure.											none	0.04	
8/6/12	18:24	X182.2C1	184.9	182.2	No compass calibration - Bluetooth failure.											none	0.04	
8/7/12	12:38	X181.7C1	184.4	181.7	12:22	235	9.1	0.04	6.84	121	268	146.38	NR	3.4	1.1	0.04		
8/7/12	13:35	X180.3C1	183.3	180.3	13:14	376	9.0	0.02	5.02	62	253	190.78	NR	0.5	1.5	0.04		
8/7/12	14:44	X178.9C1	182.9	178.9	14:31	343	41.0	0.12	5.34	358	175	177.70	2.24	0.3	1.3	0.12		
8/7/12	15:41	X176.8C1	179.5	176.8	15:28	297	14.6	0.05	6.65	47	231	184.20	0.74	0.3	0.1	0.05		
8/7/12	16:37	X176.1C1	178.5	176.1	16:24	340	39.6	0.12	6.35	358	186	188.22	1.83	0.6	3.1	0.12		
8/8/12	12:07	X173.9C1	176.5	173.9	11:55	327	8.5	0.03	5.89	198	294	95.60	NR	0.6	1.5	0.04		
8/8/12	15:16	X167.0C1	170.1	167.0	15:04	297	8.2	0.03	5.86	102.65	283	180.37	NR	1.0	0.0	0.04		
8/8/12	16:03	X164.5C1	168.1	164.5	15:51	309	16.7	0.05	6.34	178.77	359	539.99	0.85	1.3	0.8	0.05		
8/10/12	15:03	X150.2C1	153.7	150.2	14:53	252	10.6	0.04	7.44	274	305	31.41	0.57	0.4	3.7	0.04		
8/10/12	16:07	X148.7C1	152.1	148.7	15:54	321	20.1		5.83	285	283	357.46	1.08	1.9	3.3	bad	0.04	
8/10/12	18:03	X144.8C1	148.3	144.8	17:50	342	16.7		6.46	283	270	346.53	0.76	1.5	2.7	bad	0.04	
8/12/12	13:12	X142.3C1	146.6	142.3	12:57	296	14.3		6.65	235	230	354.79	0.73	0.7	2.4	bad	0.04	
8/12/12	14:58	X140.2C1	143.5	140.2	14:46	349	8.3	0.02	6.28	180	222	42.23	NR	0.3	1.7	0.04		
8/12/12	16:29	X138.9C1	142.2	138.9	16:07	349	21.8		6.38	230	247	17.52	0.85	0.3	1.3	bad	0.04	
8/12/12	17:13	X138.5C1	141.9	138.5	16:59	339	4.9	0.01	5.94	233	236	2.58	NR	0.9	1.4	0.04		
8/13/12	12:54	X136.7C1	140.0	136.7	12:36	384	6.2	0.02	7.25	9	255	245.80	NR	1.0	2.2	0.04		
8/13/12	13:58	X135.7C1	139.0	135.7	13:45	321	6.4	0.02	5.8	234	192	318.28	NR	2.8	2.5	0.04		
8/13/12	14:48	X135.4C1	138.7	135.4	14:35	325	20.4		5.16	174	195	21.06	1.22	0.3	2.6	bad	0.04	
8/13/12	16:14	X134.3C1	137.6	134.3	15:58	423	45.0		5.64	214	214	0.43	1.88	0.7	4.5	bad	0.04	
8/13/12	17:41	X131.8C1	135.0	131.8	17:26	304	31.5		6.67	241	253	12.54	1.55	2.0	3.6	bad	0.04	
8/14/12	13:14	X130.9C1	134.1	130.9	13:02	302	15.2		5.41	286.74	255	328.44	0.93	0.7	3.8	bad	0.04	
8/14/12	14:05	X130.5C2	133.8	130.5	13:47	359	32.3		6.27	268.32	248	339.80	1.43	0.6	4.2	bad	0.04	
8/14/12	15:17	X129.4C1	132.6	129.4	15:05	323	112.2		5.87	251.61	206	314.18	5.92	0.0	7.3	bad	0.04	
8/14/12	17:00	X126.6C1	129.7	126.6	16:47	340	42.8		5.17	237.92	228	350.49	2.43	0.6	2.8	bad	0.04	
8/15/12	12:50	X124.4C1	128.1	124.4	12:32	384	105.4		5.59	231.96	207	334.67	4.9	0.3	5.2	bad	0.04	
8/15/12	13:40	X123.3C1	126.8	123.3	13:29	310	29.4		5.14	218.71	208	349.45	1.85	1.6	4.4	bad	0.04	
8/15/12	14:27	X120.7C1	122.7	120.7	14:16	321	11.1	0.03	5.28	47.23	217	170.07		1.3	0.2	0.04		
8/15/12	15:59	X119.2C2	122.6	119.2	15:47	350	1.9	0.01	5.6	154.54	197	42.04		1.4	1.6	0.04		
8/16/12	12:54	X116.4C1	119.9	116.4	12:41	369	6.0	0.02	5.94	73.18	214	141.03		0.3	1.3	0.04		
8/16/12	14:15	X113.0C1	116.6	113.0	13:54	354	18.0	0.05	5.53	6.92	183	176.05	0.92	0.6	0.8	0.05		
8/16/12	16:38	X110.0C1	113.6	110.0	16:24	415	18.3	0.04	5.15	13.16	193	179.41	0.86	0.0	1.2	0.04		
8/17/12	14:57	X106.7C1	110.5	106.7	14:44	376	24.9	0.07	5.15	22.99	203	179.85	1.29	1.1	3.3	0.07		
8/17/12	17:36	X104.8C1	108.3	104.8	17:25	308	33.1	0.11	5.57	357.75	168	169.97	1.93	0.0	3.6	0.11		
8/18/12	13:12	X103.0C1	107.1	103.0	13:00	356	10.4	0.03	5.61	12.39	180	167.72		1.7	0.5	0.04		
8/18/12	14:22	X102.4C1	106.1	102.4	13:46	386	59.2		5.8	236.97	232	355.44	2.64	1.3	4.4	bad	0.05	
8/18/12	16:21	X101.5C1	105.3	101.5	16:08	323	0.7	0	6.3	135.01	208	73.13		0.3	0.2	bad	0.06	
8/18/12	18:07	X101.0C2	104.7	101.0	17:55	342	19.5	0.06	6.77	349.34	162	172.46	0.84	0.0	1.3	0.06		
8/19/12	12:07	X100.4C3	104.1	100.4	11:53	365	20.3	0.06	5.2	347.4	162	174.30	1.07	0.3	1.5	0.06		
8/19/12	15:40	2RIVC1	--	98.2	15:10	641	203.5	0.32	6.39	324.96	181	216.52	4.97	1.1	1.9	0.32		
8/20/12	14:13	X95.0C1	98.4	95.0	13:59	410	112.0	0.27	6.31	351.14	188	196.78	4.33	8.3	3.7	0.27		
8/20/12	16:42	X94.0C2	97.0	94.0	16:28	365	74.9	0.21	6.06	63.48	249	185.29	3.39	3.6	0.2	0.21		
8/21/12	14:12	X87.7C2	91.6	87.7	13:55	372	171.0		5.68	340.52	158	177.17	8.09	1.9	5.4	bad	0.31	4.7
8/21/12	16:51	X86.9C3	91.0	86.9	16:31	417	134.9	0.32	6.17	358.12	188	189.77	5.24	1.9	2.8	0.32		
8/22/12	16:41	X84.6C4	88.4	84.6	16:21	379	49.2	0.13	7.99	37.53	215	177.42	1.63	4.0	2.2	0.13		
8/22/12	18:01	X81.2C2	85.4	81.2	17:47	387	130.0	0.34	5.92	296.14	107	170.44	5.67	2.1	5.4	0.34		
8/23/12	14:24	X80.0C1	84.4	80.0	14:07	327	46.7	0.14	6.43	330.48	152	181.64	2.22	2.5	0.3	0.14		
8/23/12	17:29	X78.0C1	82.3	78.0	17:16	330	35.7	0.11	5.69	1.85	154	152.09	1.9	1.2	0.2	0.11		
8/24/12	14:28	X76.0C1	80.0	76.0	14:13	358	69.7	0.19	6.14	356.76	189	192.12	3.17	1.7	3.4	0.19		
9/14/12	17:05	X176.8C1	179.5	176.8	16:54	303	9.4	0.03	5.47	41.45	231	189.11		0.66	1.4	0.04		
9/14/12	17:47	X176.2C1	178.5	176.2	17:35	332	18.6	0.06	5.08	11.02	185	174.14	1.1	1.81	2.8	0.06		
9/15/12	13:17	X184.1C1	187.2	184.1	13:06	302	4.2	0.01	6.07	307.11	273	325.58		2.65	0.3	0.04		
9/15/12	14:05	X183.4C1	186.2	183.4	13:52	375	2.7	0.01	3.72	221.76	269	47.02		1.33	3.2	0.04		
9/15/12	14:57	X182.2C1	184.9	182.2	14:45	337	9.7	0.03	4.91	290.43	263	332.21		0.59	1.4	0.04		
9/15/12	15:52	X181.7C1	184.4	181.7	15:41	314	6.1	0.02	5.48	183.5	267	83.25		2.23	3.8	0.04		
9/15/12	16:41	X180.3C1	183.3	180.3	16:28	368	1.8	0	3.54	138.43	252	113.31		1.09	2.2	bad	0.06	0.9
9/15/12	17:55	X178.9C1	182.9	178.9	17:43	328	24.6	0.08	4.26	352.89	173	180.44	1.76	0.61	0.3	0.08		
9/16/12	14:50	X173.9C1	176.5	173.9	14:39	317	12.9	0.04	5.22	305.18	295	349.55	0.78	0.63	2.2	0.04		
9/16/12	16:29	X170.0C1	173.1	170.0	16:17	318	7.7	0.02	6.39	307.88	284	336.31	0.78	0.94	1.6	0.04		
9/16/12	17:33	X167.0C1	170.1	167.0	17:21	327	8.5	0.03	5.13	294.57	283	348.28	0.78	0.92	2.3	0.04		
9/17/12	15:19	X164.5C1	168.1	164.5	15:08	310	22.0	0.07	6.4	164.06	359	555.00	1.11	2.26	0.6	0.07		
9/29/12	15:20	X148.7C1	152.1	148.7	15:05	343	6.9	0.02	6.47	209.71	284	74.07		2.05	3.0	0.04		

Date	Mid-point time	Site	Project River Mile	Brailey River Mile	Loop Test Results											measured bed v	inter-polated bed v	calculated % correction
					Start time	Duration, s	DMG, ft	Velocity, ft/s		Direction, deg			% Corr	% bad BT	out-back difference	see note to right		
								Bed	Flow	Bed	Flow	Diff						
9/29/12	16:51	X142.3C1	145.7	142.3	16:38	307	76.9		6.43	230.05	231	0.93	3.9	1.63	9.9	bad	0.04	
9/29/12	17:45	X138.9C1	142.2	138.9	17:31	400	74.3		6.5	252.86	248	354.88	2.86	1.75	6.3	bad	0.04	
9/30/12	13:56	X136.7C1	140.0	136.7	13:39	307	2.9	0.01	7.1	111.11	258	146.87		1.95	1.0	0.04		
9/30/12	15:00	X134.3C1	137.6	134.3	14:44	339	31.7		5.73	203.75	212	8.27	1.63	0.59	2.6	bad	0.04	
10/1/12	13:40	X131.2C1	134.3	131.2	13:25	364	65.9		7.4	258.28	267	8.61	2.45	1.93	6.6	bad	0.04	
10/1/12	17:02	X123.3C1	126.8	123.3	16:51	311	74.0		4.62	205.53	207	1.95	7.32	2.89	11.0	bad	0.04	
10/1/12	17:42	X120.7C1	124.1	120.7	17:31	318	48.2		4.45	219.14	219	359.53	3.41	4.42	10.1	bad	0.04	
10/3/12	14:47	X116.4C1	119.9	116.4	Loop test module wont execute - recorder issue											none	0.04	
10/3/12	15:53	X113.0C1	116.6	113.0	Loop test module wont execute - recorder issue											none	0.04	
10/3/12	16:41	X110.0C1	113.6	110.0	Loop test module wont execute - recorder issue											none	0.04	
10/3/12	17:33	X106.7C1	110.5	106.7	Loop test module wont execute - recorder issue											none	0.04	
10/4/12	14:10	X103.0C1	107.1	103.0	14:20	320	13.6	0.04	5.1	Loop transect with upstream DMG						0.04		
10/4/12	15:58	X99.6C3	103.5	99.6	15:41	328	8.6	0.03	5.2	Loop transect with upstream DMG						0.04		
10/5/12	14:06	X95.0C1	98.4	95.0	13:54	326	80.2	0.25	5.09	359.82	186	186.62	4.83	4.6	3.3	0.25		