Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Groundwater Study
Study Plan Section 7.5

2014-2015 Study Implementation Report

Appendix D

December 5, 2014 Technical Team Meeting Notes and Presentation

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

Geo-Watersheds Scientific

October 2015

SUSITNA-WATANA HYDRO

Meeting Notes
Groundwater Technical Team (TT) Meeting
Groundwater (Study 7.5), Riparian Instream Flow (Study 8.6)
December 5th, 2014

LOCATION: Teleconference/Webinar

TIME: 9:00 am to 12:00 pm AKST

SUBJECT: Groundwater Study (Study 7.5)

Goal: Further discussion and question/answer session on Groundwater Study (Study 7.5) topics and related aquatic and riparian resource applications.

Attendees: **Betsy McCracken** USFWS**, Betsy McGregor** AEA**, Bob Henszey** USFWS**, Chris Holmquist-Johnson** USGS**, Dan Smith** AEA**, Dara Glass** CIRI**, David Kroto** Tyonek**, Dirk Pedersen** Stillwater**, Doug Ott** AEA**, Dudley Reiser** R2**, Dustin Murray** ADF&G**, Felix Kristanovich** Environ**, Fred Winchell** Louis Berger**, Greg Auble** USGS**, Jan Konigsberg** Alaska Hydro**, Jim Munter** J.A. Munter Consulting**, Joe Klein** ADF&G**, Kevin Fetherston** R2**, Kevin Petrone** R2**, Leanne Hanson** USGS**, Lyle Zevenburgen** Tetra Tech**, Matt LaCroix** EPA**, Michael Lilly** GWS**, Michael Mazzacavallo** R2**, Rachel Thompson** AEA**, Sarah O'Neal** Trout Unlimited**, Sue Walker** NMFS**, Tim Ruga** AKRF**, Tyler Rychener** Louis Berger**, Wayne Dyok** AEA**, Wayne Swaney** Stillwater

The following meeting notes provide summary information regarding the discussions that occurred as part of the Groundwater TT Meeting. Additional materials including the meeting agenda and presentations are available under the "previous meetings" tab (link provided under the meetings tab) on the Project website (http://www.susitna-watanahydro.org/).

<u>Introductions and Objectives of Meeting</u>

Dudley Reiser opened the meeting with introductions and noted that the purpose of the meeting was to follow up on questions raised during the October 2014 ISR meetings regarding the analytical steps and water table mapping that were being completed as part of the Groundwater Studies (Study 7.5). There are also two Technical Memorandums (TM's) filed in September 2014 that provided additional data since the ISR, these were partially discussed as a response to questions during the October ISR meetings.

<u>Summary of Groundwater Study and Discussion of New Materials Post – ISR Meeting</u>

Michael Lilly stepped through slides 1-32, a brief overview of the study, basic groundwater/surface-water (GW/SW) interactions, discussing observational (spatial) scales, time scales, upwelling analysis methods including transects, water table mapping and groundwater (GW) MODFLOW modeling, example groundwater elevations and surface-water stage point maps and groundwater water-table contour maps. The common definition for the water table in groundwater hydrology is the top of the water surface of an unconfined aquifer, at the elevation where the water is at atmospheric pressure. After these slides were reviewed, the meeting was opened up to questions.

Questions and Discussion of Materials Presented

Jim Munter questioned the alignment of transects on Slide 26. At the beaver pond hinge point between Slough 6A and Susitna River, the water table is fairly flat but it also looks like flow is north to south. It's important to have the transect models aligned in the direction of GW flow. The west side of Slough 6A looks good, with a steep gradient to the slough, but then it flattens out in the direction of the well. Jim Munter asked how this would be addressed.

Michael Lilly responded that the purpose of the transects is to determine the kinematic pressure-wave response back into the groundwater system as the Susitna River stage changes, with less focus on the groundwater flow paths as the pressure response does not follow the flow paths, see Figure 15 on page 28 of the GW-RIFS Tech Memo (TM) (GWS and R2 2014a). Aerial photos and on-the-ground observations are also used to develop contours during a particular time frame.

Jim Munter commented that the beaver pond is oriented east-west; water is trying to flow north to south and the beaver pond dams it up. The problem in doing a transect model is that there is leakage out the south side, and orientation of that transect is unable to simulate the water flow through the system. It breaks the rules of transect modeling. It is a deterministic model, not a hypothetical model. Jim suggested a model segment between the west side of Slough 6A on west side of monitoring wells using Slough 6A as a boundary. He stressed that it is important that the model orientation is valid if it is to be used in predicting.

Michael Lilly responded that the purpose of the modeling is to look at changes in the GW system, when there have been changes to the surface water (SW) system. The modeling is intended to better understand the process interactions, not to predict the fluxes through the system. The GW/SW interactions are dominated by transient stage differences (changing over time) between GW and SW.

Jim Munter responded that the model is a deterministic model trying to simulate actual flow and doesn't understand it to be a hypothetical model to understand process understanding. He again noted that it is important that the model be physically valid in terms of appropriately simulating transient and 3-D flow systems known to be there. It is a challenge.

Jim Munter moved on to discuss Slide 24, agreeing on the importance of understanding hydrology during the previous weeks (of the contour period) but suggested a re-look at the contouring at the bulge in the middle of the island, which may be smaller and more of a saddle type feature. He noted it was important to process understanding to know the recharge during September rains and he would be interested in modeling what is related to river stage versus precipitation recharge.

Michael Lilly responded that FA-104 (Whiskers Slough), FA-115 (Slough 6A), FA-128 (Slough 8A), and FA-138 (Gold Creek) do have summer precipitation gages to evaluate recharge. He also noted it is important to look at whether the river is going up due to upstream events or if there is a more localized response due to local precipitation. This precipitation data was important for a variety of reasons, including the influence on local runoff contributing to GW recharge and SW stage changes. The precipitation data indicates precipitation at the focus area scale varies between Focus Areas.

Jim Munter commented on the importance of having a time series of water table maps using data from instrumented sites, maybe with dashed contours if don't know exactly. Using dashed contours is ok even though there is more interpolation to do.

Joe Klein offered another suggestion to help improve interpretation, by including two small inset graphs or histograms of antecedent conditions – one to indicate stage and one to indicate precipitation from the previous week.

Bob Henszey commented on Slide 24, regarding the riparian transect orientation across the mound, and echoed Jim Munter's concern about transect orientation and interpretation. He asked how the contours were generated.

Michael Lilly responded that the contours were drawn by hand using water table information, topography, aerial photos, field observations, and professional judgement. Bob Henszey is ok with hand drawings at this point in time as long as it will be modeled in a repeatable fashion down the road.

Jim Munter commented that hand drawn contours are better than computer-generated contours. He then referred to Slide 28, talking about upwelling, downwelling, and microscale understanding, and asked for information about how field operations will be incorporated into model verification or calibration.

Michael Lilly referred to Figure 4.3-32 (FA-128 [Slough 8A]) and Figure 4.3-33 (FA-138 [Gold Creek]) in the GW-IFS TM (GWS and R2 2014b). A review of the temperature and hydrology data gathered provides a good understanding of the temperature regime between upwelling and downwelling areas. Understanding these differences is a way to validate upwelling and downwelling areas.

Jim Munter asked if there are any stream measurements from Whiskers Slough to compare to GW discharge model output.

Michael Lilly referenced the GW-IFS TM (GWS and R2 2014b). Paired stream reach measurements were collected to measure small changes in discharge so that an increase or decrease in the slough could be seen between measurements.

Jim Munter mentioned a comment made during the ISR meeting regarding a section of the GW-IFS TM (GWS and R2 2014b) discussing downwelling determined by temperature measurements, where for a particular site when looked at the hydraulic gradient (Figure 4.3-32), they were either flat or upward over the entire time. There is a concern that temperature was a reflection of stagnant GW. And with the well level being slightly higher than the SW level, it is hard to conclude that there is downwelling. One could alternatively interpret that if there is not much flow, as winter progresses the shallow subsurface would get colder.

Michael Lilly responded that when all the data is considered, it suggests downwelling. Temperature and water level data together is important if the hydraulic gradient is really small from icing effects. Winter ice processes makes the data analysis more challenging as stage increases can occur when ice constricts or blocks the channel. Using the temperature and water level measurements from GW and SW together are needed to help understand the GW/SW interactions.

Jim Munter responded that the GW well had higher levels than SW levels by slight amount that go up with ice impacts, flat without much flow, so it is hard to conclude that there is downwelling with that data. The alternative interpretation would be that if it is flat there is not much flow so as winter progresses the shallow subsurface gets colder and colder which shows up in purple in the figure below, but not sure showing there is any downwelling actually occurring. The GW model may help understand what is going on here. The piezometer is in a good location based on the data shown.

Michael Lilly responded that when considering all the data, it suggests downwelling is occurring there. Temperature and water level data together is important if the hydraulic gradient is really small from icing effects.

Kevin Petrone suggested to make the Figure more clear, calculating the hydraulic gradient between the GW well and SW, which could probably be done every 15 minutes and put in a chart.

----- BREAK ----- 10:25-10:35

Michael Lilly discussed Figure 13 in the GW-RIFS TM (GWS and R2 2014a) as being another example of a downwelling area. In FA-128 (Slough 8A), the lower riparian transect and the lower aquatic transect share observation well and the combined data collection helps to better understand the system.

Kevin Petrone then described an interesting upwelling example that responds to ice disturbance in Middle Side Channel 8A, using Figure 2.0-5 and Figure 4.3-32 (GWS and R2 2014b). The objective of the analysis was to look at how stream temperature changes with changes in mainstem flow and elevations in GW wells and SW. At this site the hyporheic profile remains quite cold through the winter period with temperature decreases in the mid-January period. That is associated with an increase in stage, and the well also responds to that stage, so overall in this location the streambed profile is responding to the temperature of the side channel and responding less to influence of the well. The hydraulic gradients are subtle but the well and SW are quite close; seems the streambed profile is representative of SW and is cold through the winter. The flip side is the temperature increases quite rapidly just after break up.

Kevin Petrone then described an upwelling example that responds to ice disturbance, using Figure 2.0-9 and Figure 4.3-33 (GWS and R2 2014b) which displays side water temperature and stage data in Upper Side Channel 11 in FA-138 (Gold Creek).

Kevin Petrone noted that the Upper Side Channel 11 is a chum spawning area and represents an upwelling area. The figure illustrates what may have occurred as a result of ice jamming in the mainstem that diverted flow through the slough so there was a pulse of mainstem water through this slough – can see increase in SW and GW well stage corresponding to a drop in temperature. With recession from discharge peak, can then see temperature increased quickly again up to 4˚C range and stayed there throughout the winter. Can see another blip over short period that occurred maybe during break up where an ice disturbance event occurred resulting in a slight decrease in temperature.

Kevin Petrone highlighted differences in summer condition upwelling and downwelling. During summer, upwelling tends to moderate the temperatures, and during the winter, upwelling is associated with warmer temperatures but it also acts to moderate temperature increases during the summer. In a downwelling site, temperatures are colder in the winter and warmer in the summer, changing more dramatically at a downwelling site.

Dudley Reiser tied this in to the IFS program, commenting that this data will be used for effective spawning/incubation analysis and the temperature regimes that will be present under different flow conditions with and without Project for incubation and fry emergence.

Greg Auble asked how this analysis will be done post-Project considering accretion and bed elevation changes over 25 and 50 years.

Dudley Reiser responded that if modeling indicates that a channel would not be watered, then it would become non-habitat. EFDC will provide temperature modeling to determine how intergravel conditions will be influenced.

Michael Lilly then reviewed the work being done on lateral hydraulic gradients. The importance of the lateral hydraulic gradients relates to defining the edge of the effect of riverine dominated influences, which we are referring to as a hinge-line, or point when looking at a cross-section perpendicular to the river. Above this hinge line the groundwater system is dominated by upland groundwater conditions. Below the hinge line it is riverine dominated and there is a transition zone between upland and riverine dominated zones.

Greg Auble agreed with this concept and the approach being taken and that the geomorphology changes at the upper end of slough and channels will further complicate the analysis.

Jim Munter commented that the data in the upper side channel are good – there is no doubt that there is upwelling occurring based on the temperature data. He suggested that areas be classified as either upwelling or not upwelling. For areas where it is unclear whether or not there is upwelling/downwelling, leave it as an unknown; for example, not sure there is data to support that downwelling is occurring in Slough 8A.

Dudley Reiser tied this in with the habitat analysis being done for Fish and Aquatics IFS. Slide 30 shows areas influenced by upland versus riverine. Slides 31-32 prepared by Miller Ecological Associates show areas of upwelling at different flows. This type of analysis will rely on input from the Groundwater Study and will provide input into habitat modeling. Different flow conditions, time steps, and seasonality will be looked at. HSC fieldwork has collected vertical hydraulic gradient (VHG) measurements that can be used to show the influence of upwelling and where fish are or are not and what is considered spawning habitat. The amount of spawning habitat in a location would be defined by the overlapping areas meeting HSC criteria with GW upwelling.

Chris Holmquist-Johnson asked how the GW versus riverine effect will be evaluated when the Project hydrograph is flip flopped.

Dudley Reiser responded that the short answer is that it will be pieced together from data and professional judgement. Not sure how it will come together yet but the first step is to get the models developed and look at existing conditions for certain flow conditions and timescales/seasonality, then Project operations will be brought in. How GW flows are expected to change will be evaluated using the contour maps. The contour maps are a powerful way to evaluate potential Project effects.

Greg Auble commented that he is skeptical about the use of ancillary observations in interpretations used to produce water table maps, because there are no post-Project observations.

Betsy McCracken commented that the agencies had asked for a full suite of microhabitat variables to be assessed, and that downwelling has not been ruled out as influential to habitat selection.

Dudley Reiser responded that at the January ISR Meeting, the microhabitat variables TM filed with FERC in September 2014 will be discussed which looks at whether fish congregations are associated with a variety of parameters outside of the standard depth, velocity, and substrate criteria.

Jim Munter commented that this segment of the presentation hit on a lot of high points, and that the map on Slide 22 demonstrates the bullet points. The south end has tightly packed contours showing a classic upland GW dominated flow system, with an island as a whole different flow system with spaced out contours following the trend of the river gradient. The point being made is that a map like this can be used to classify riverine versus upland dominance, and with data sets, can scale up to other reaches that do not have this kind of data. Some sites are more complicated but this approach is right on.

Bob Henszey commented on his concern regarding the north side of the river in Slide 22, with corresponding aerial photo in Figure 9 (GWS and R2 2014a), where Michael Lilly had proposed the direction of GW flow between two sloughs at this transect indicated the primary gradient was lateral, and the GW contours drawn here are opposite. The concern is with using transects without looking at other drivers.

Michael Lilly responded that groundwater flow lines are not being used for locations of transect; the transect is composed of observation points along the pressure pulse of the river to see if there are changes laterally for that pressure boundary as the river changes in stage. The GW/SW system is dynamic and transient, so flow lines vary seasonally and with changing river stage. This would make it difficult to place wells along a single flow line. The purpose of each transect is to look at lateral pressure relationships. The combination of GW and SW measurements (water level, discharge, and temperature) and information from aerial surveys and time-lapse cameras will help provide enough information to understand the GW/SW process relevant for the aquatic and riparian resource questions.

Regarding Slide 38 showing the temperature profile of FA-138, Tim Ruga asked, why the temperature is consistently at 4˚C and does not seem to move above or below except when one slug of water came through.

Michael Lilly responded that the average GW temperature in this area and what you see in the lateral wells is around 4˚C plus or minus 1˚C.

Tim Ruga responded that there is a boundary issue here because 4˚C is probably an average of river temperature. A boundary temperature condition may help understand the temperature conditions and be an appropriate approach.

Michael Lilly responded that the wells in this area in uplands away from the river, including homeowner wells, indicate GW temperature varies from 2 to 5˚C, and a general average is around 4˚C. The data is currently being reviewed so temperature information can be characterized.

Felix Kristanovich asked what Michael Lilly's gut feeling was on the magnitude of migration of the hinging point between GW and SW with Project impacts.

Michael Lilly responded that with operational scenarios that increase stage in winter, it could shift upland slightly depending on the location and ice processes. In summer it may change the other way toward the river with a lower stage. It will not be sensitive to diurnal changes but perhaps monthly and seasonally.

Jim Munter reiterated his concern with the transect modeling. The model will not be able to be used in a predictive capacity on different timescales if the transects are not lined up along flow lines. In this case it is limited to being a hypothetical model for understanding processes instead of A predictive model.

Tim Ruga added that there is also a question as to whether a hypothetical model like that could be used for upscaling.

Michael Lilly explained that it is one tool in the toolbox to understand what will happen at the river segment scale, along with all the empirical analysis, data, GW modeling at cross section areas, and upscaling from Focus Areas.

Greg Auble requested, from a riparian vegetation perspective, a table showing vegetation plot locations including the GW info available for each plot, whether near GW wells or no associated GW data. It would be helpful for reviewers of vegetation studies to see a draft of this table before the end of next field season.

Kevin Fetherston responded that a TM has been drafted that addressed that question – how representative is the GW sampling going to be – and would be released in the near future.

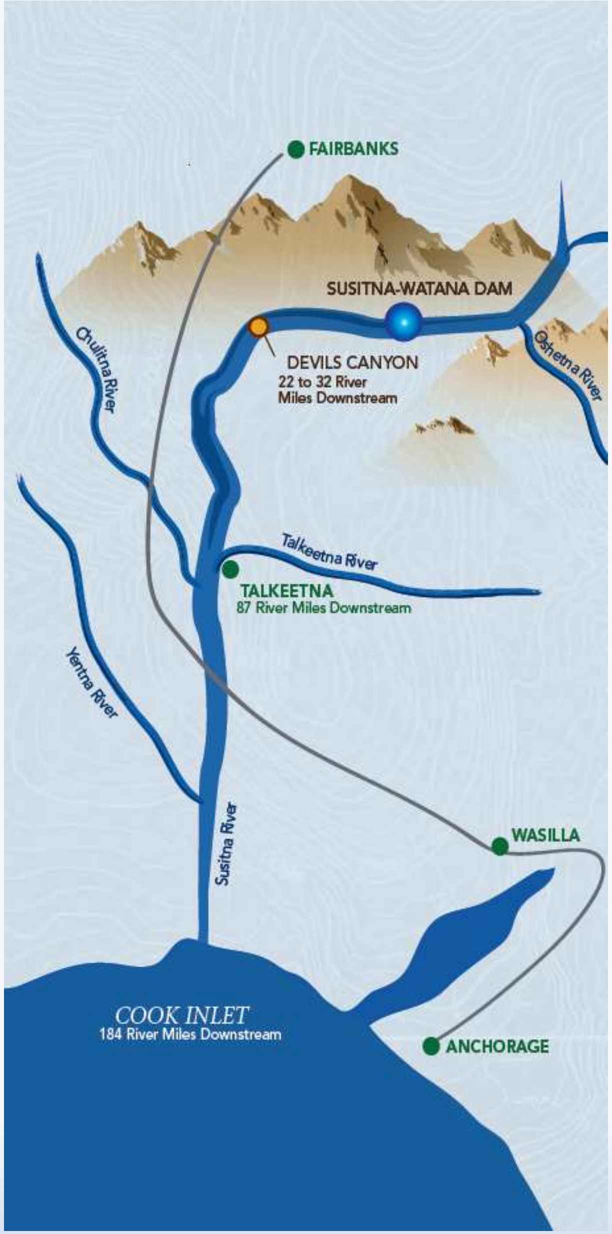
Bob Henszey appreciated hearing of the new TM. From his standpoint it looks like the Groundwater Study alone is not going to provide the level of detail needed. Kevin Fetherston added that the TM will include a description of total number of plots, address the type of sampling along transects, and include elevation gradients between wells. Greg Auble said that is exactly what he was looking for.

Michael Lilly concluded the meeting summarizing that modeling limitation is an important issue. The groundwater modeling is intended to help support empirical data analysis and improve GW/SW process understanding. The modeling efforts and empirical analysis will be used to answer key questions regarding how the system works and potential Project impacts.

REFERENCES

Geo-Watersheds Scientific (GWS) and R2 Resource Consultants. 2014a. Groundwater and Surface-Water Relationships in Support of Riparian Vegetation Modeling , Technical Memorandum, Study 7.5. Susitna-Watana Hydroelectric Project, FERC No. P-14241. Prepared for Alaska Energy Authority, Anchorage, Alaska. September 2014. 58 pp. http://www.susitna-watanahydro.org/wp-content/uploads/2014/09/07.5_GW_GWS_T5_TM_Riparian_Final_Draft_20140926.pdf.

Geo-Watersheds Scientific (GWS) and R2 Resource Consultants. 2014b. Preliminary Groundwater and Surface-Water Relationships in Lateral Aquatic Habitats within Focus Areas FA-128 (Slough 8A) and FA-138 (Gold Creek) in the Middle Susitna River, Technical Memorandum, Study 7.5. Susitna-Watana Hydroelectric Project, FERC No. P-14241. Prepared for Alaska Energy Authority, Anchorage, Alaska. September 2014. 136 pp. http://www.susitna-watanahydro.org/wp-content/uploads/2014/09/07.5_GW_GWS_T6_TM_Aquatic_Hydro_Final_Draft_20140925.pdf.



Technical Team Meeting

Study 7.5 Groundwater

December 5, 2014

Prepared by

GW Scientific

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Study 7.5 Technical Team Meeting - Agenda

- 9:00 – 9:10 Introductions and Objectives of Meeting
- 9:10 – 9:40 Summary of Groundwater Study and Discussion of New Materials Post – ISR Meeting – M. Lilly
  - Analytical Steps
  - Water Table Mapping
- 9:40 – 10:15 Questions and Discussion of Materials Presented
- 10:15 – 10:25 Break
- 10:25 – 10:45 Overview of Technical Memoranda – M. Lilly
- 10:45 – 11:45 Open Discussion and Questions on Groundwater Topics - All
- 11:45 – 12:00 Meeting Summary, Next Steps, Adjourn – M. Lilly

Study 7.5 Technical Team Meeting - Agenda

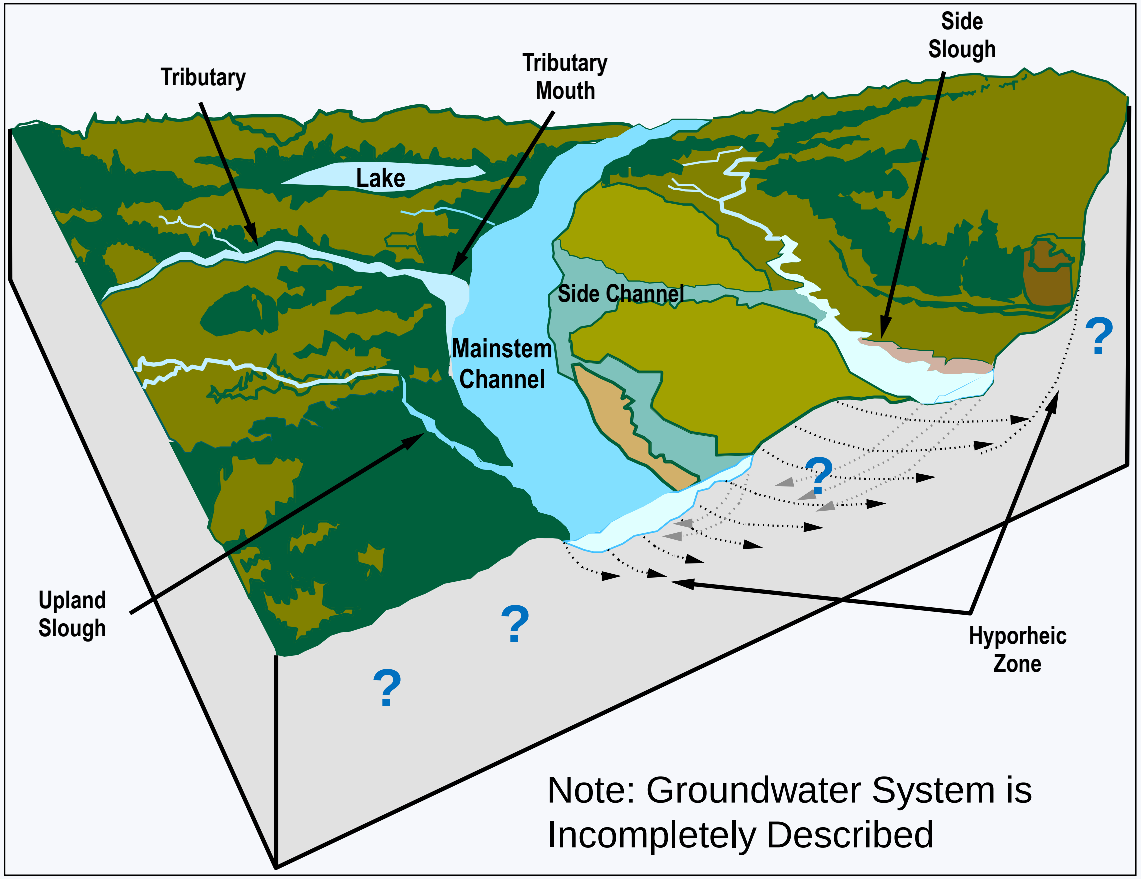
- **9:00 – 9:10 Introductions and Objectives of Meeting**
  - Introductions
  - Meeting Objectives
    - Further discussion and question/answer session on Groundwater Study topics and related aquatic and riparian resource applications
    - Overview of new material Post – ISR Meeting

Study 7.5 Objectives

- **Synthesize** historical and contemporary groundwater data available for the Susitna River groundwater and groundwater dependent aquatic and floodplain habitat, including that from the 1980s and other studies including reviews of **GW/SW interactions in cold regions**
- Use the available groundwater data to **characterize large-scale geohydrologic process-domains/terrain of the Susitna River** (e.g., geology, topography, geomorphology, regional aquifers, shallow groundwater aquifers, GW/SW interactions)
- **Assess** the potential effects of **Watana Dam/Reservoir** on **groundwater and groundwater-influenced aquatic habitats** in the vicinity of the proposed dam
- Work with other resource studies to **map groundwater-influenced aquatic and floodplain habitat** (e.g., upwelling areas, springs, groundwater-dependent wetlands) within the Middle River Segment of the Susitna River including within selected Focus Areas (see Fish and Aquatic Instream Flow Study Section 8.5.4.2.1.2)
- Determine the **GW/SW relationships of floodplain shallow alluvial aquifers** within selected Focus Areas as part of the **Riparian Instream Flow Study** (Riparian Instream Flow Study, Section 8.6)
- Determine **GW/SW relationships** of **upwelling/downwelling** in relation to spawning, incubation, and rearing habitat (particularly in the winter) within selected Focus Areas as part of **the Fish and Aquatics Instream Flow Study** (Fish and Aquatic Instream Flow Study 8.5)
- **Characterize water quality** (e.g., temperature, dissolved oxygen [DO], conductivity) of **selected upwelling areas** that provide biological cues for fish spawning and juvenile rearing, in Focus Areas as part of the **Fish and Aquatics Instream Flow Study** (Fish and Aquatic Instream Flow Study (Study 8.5))
- Characterize the **winter flow in the Susitna River** and how it relates to **GW/SW interactions**
- Characterize the **relationship** between the **Susitna River flow** regime and **shallow groundwater users** (e.g., domestic wells)

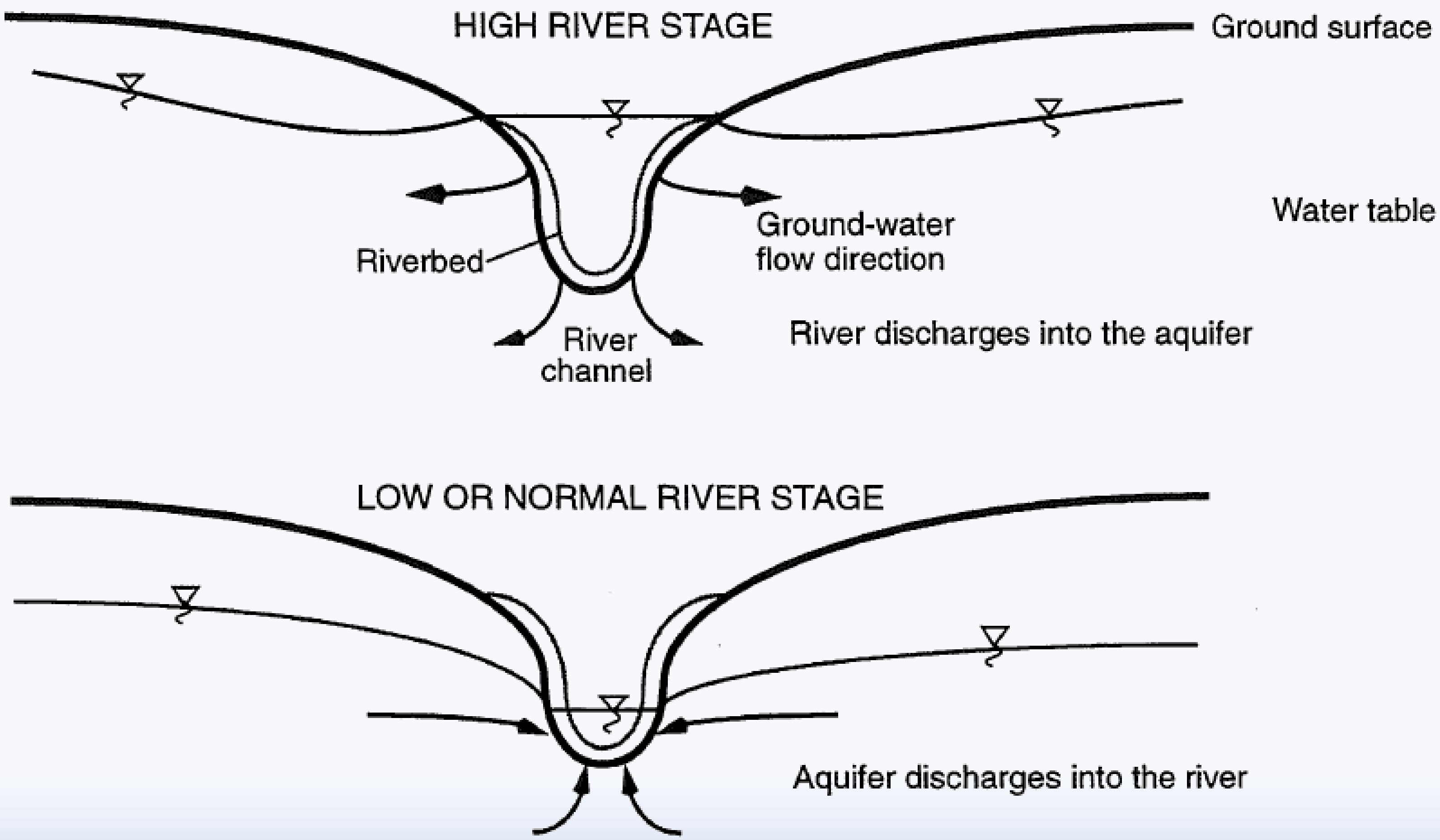
Study 7.5 Overview – Groundwater Effects on Aquatic and Riparian Resources

- Inter-Related
- Impacts on Riparian <u>And</u> Impacts on Aquatic
- Groundwater Questions Have Many Overlaps



Habitat types identified in the Middle River Segment of the Susitna River during the 1980s studies (adapted from ADF&G 1983; Trihey 1982).

Study 7.5 Overview – Groundwater/Surface-Water (GW/SW) Interactions



Study 7.5 Analysis Steps – Post ISR Materials

Supporting Materials for Discussion

- **Analysis Process Steps**
  - Aquatic Habitat, Riparian, Upscaling
- **Water Table Map Examples (Fall 2014)**
  - FA-138 (Gold Creek), FA-128 (Slough 8A)
  - FA-115 (Slough 6A), FA-104 (Whiskers Slough)
- **Discussion/Questions/Break**
- Aquatic Technical Memorandum
  - Preliminary Groundwater and Surface-Water Relationships in Lateral Aquatic Habitats within Focus Areas FA-128 (Slough 8A) and FA-138 (Gold Creek) in the Middle Susitna River
- Riparian Technical Memorandum
  - Groundwater and Surface-Water Relationships in Support of Riparian Vegetation Modeling

Study 7.5 Analysis Steps – Observation Scales

- **Aquatic and Riparian Transect Scale**
- **Focus Area Scale**
- **River Segment Scale**
- **Watershed Scale**

Study 7.5 Analysis Steps – Observation Scales

- **Aquatic and Riparian Transect Scale**
  - GW/SW Interaction Focus, Includes Basic Water Quality
  - Develop Understanding at Critical Habitat Areas
    - Aquatic – Key Spawning, Rearing Areas
    - Riparian – Key Vegetation Classes
  - Transects Perpendicular to Key Hydrologic Boundaries
    - GW/SW Interaction Are Driven By Transient "Pulses"
    - Kinematic Hydraulic Gradient Changes
    - Transient Conditions Dominate
  - Development of Process Understanding
    - Empirical Data – Mainly Continuous = Transient Processes
    - Groundwater Modeling – Process Understanding Tool
- Focus Area Scale
- River Segment Scale
- Watershed Scale

Study 7.5 Analysis Steps – Observation Scales

- Aquatic and Riparian Transect Scale
- **Focus Area Scale**
  - Multiple Focus Areas Allow Representation of Habitat Diversity
    - Both Aquatic and Riparian
  - Some Focus Areas Have Multiple Transects
    - Example: FA-128 (Slough 8A) 2-Aquatic, 2-Riparian Transects
  - Other Off-Transect Measurement Locations and General Field Observations (Aerial Images, Time-Lapse Cameras, Etc.)
  - Other Studies Empirical Information
  - Riverine Modeling Information
  - Scaling To Controlling Boundary Conditions
  - Process Variations from Riverine to Upland Dominated (most)
  - Water Table Mapping
- River Segment Scale
- Watershed Scale

Study 7.5 Analysis Steps – Observation Scales

- Aquatic and Riparian Transect Scale
- Focus Area Scale
- **River Segment Scale**
  - Primary Goal For Upscaling and Project Effects Evaluation
  - Less Data Availability – But Representative Focus Areas
  - Development of Spatial Data Sets (GIS Coverages)
    - Example: DEM, Vegetation Mapping, Geology, Habitat Zones
    - Aerial, Satellite Images
    - Thermal Infrared (TIR) Mapping, Winter Open Leads Mapping
  - River Segment Scale Modeling
    - Flow Routing Models (Winter – Ice Cover, Summer – Ice Free)
    - Temperature, Water Quality
  - Process Upscaling From Focus Areas
  - Applies to Riparian Assessment, General Understanding, Not All Models (For Example Focus Area Habitat Modeling)
- Watershed Scale

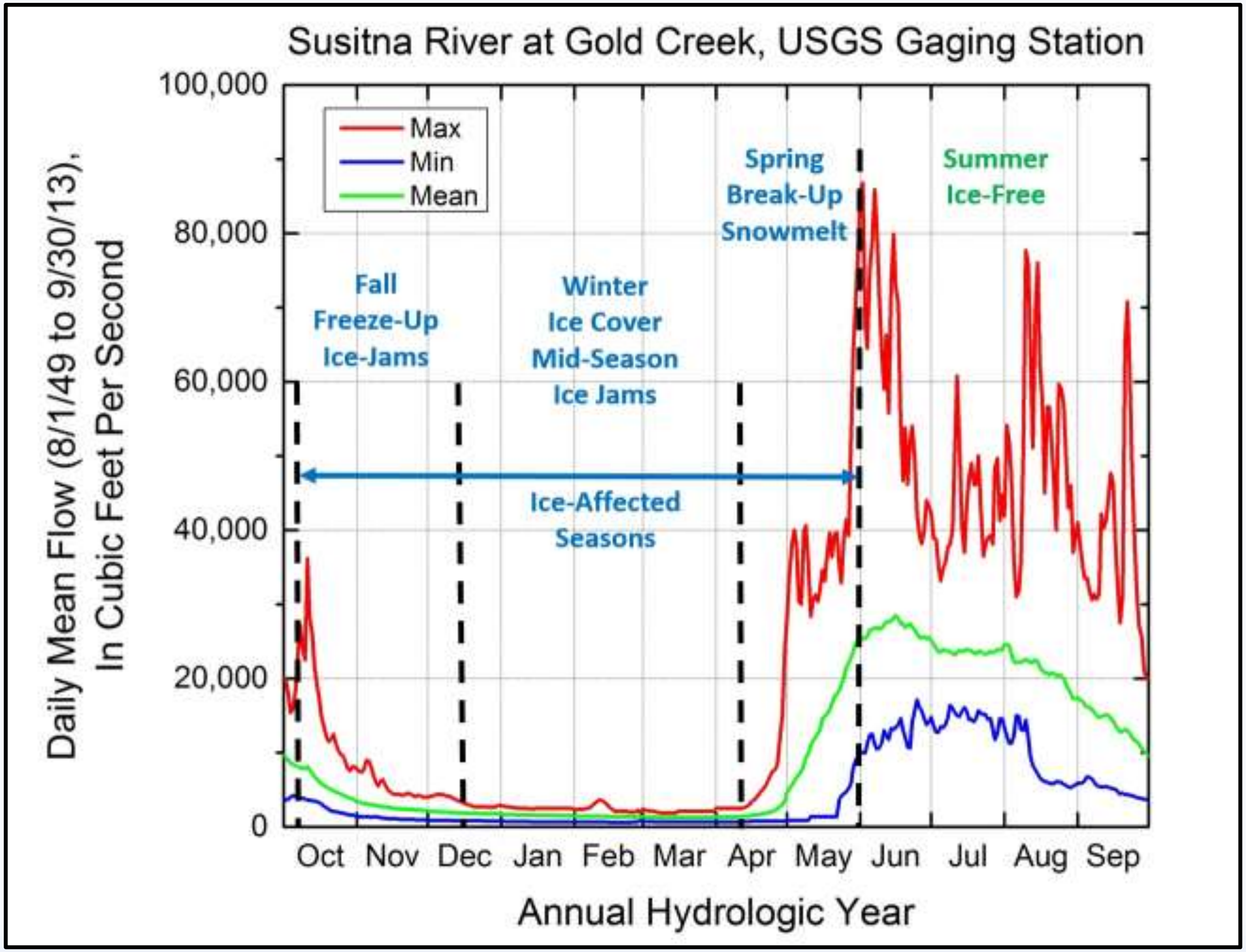
Study 7.5 Analysis Steps – Observation Scales

- Aquatic and Riparian Transect Scale
- Focus Area Scale
- River Segment Scale
- **Watershed Scale**
  - Mainly Development Of Information To Support Other Scales
  - Variations in Climate, Geology, Geohydrology, Vegetation
  - Understanding Orogeny Effects on Hydrology
    - Example: Talkeetna Mountains
  - Boundary Conditions Affecting Upland Hydrology
  - Hydrologic Boundary Conditions

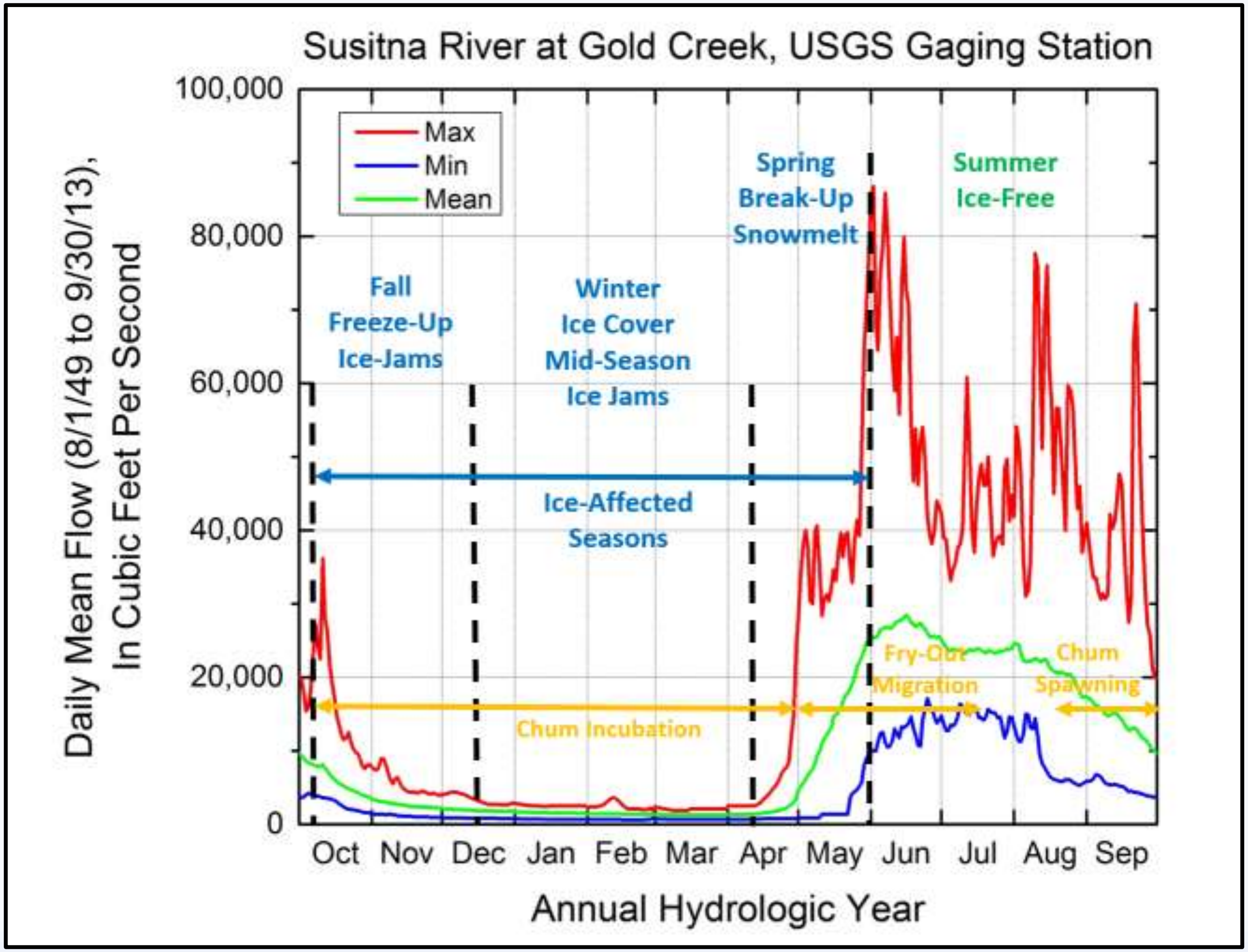
Study 7.5 Analysis Steps – Time Scales

- **Daily**
  - Diurnal Fluctuations
  - Standard Base Collection Internal = 15 minutes
    - Not All Analysis Should Be At 15 Minutes!
  - Process and Question Dependent
  - Important for Calibrating to Peaks and Pulses
- **Seasonal**
  - Annual Hydrologic Year – Winter Dominated
  - Four Primary Hydrologic Seasons
    - Fall Freeze-Up
    - Winter
    - Spring Breakup/Snowmelt
    - Summer
- Operational

Study 7.5 Analysis Steps – Time Scales - Physical



Study 7.5 Analysis Steps – Time Scales - Biological



Study 7.5 Analysis Steps – Time Scales

- Daily
- Seasonal
- **Operational**
  - Construction, Operations Period
  - Years to Decades
  - Aquatic and Riparian Systems Response Over Longer Time Scales

Study 7.5 Analysis Steps – "Upwelling"

- **Scales and Methods** =
  - **Transects**
    - Empirical Data Analysis, Groundwater Modeling (MODFLOW)
    - Primary Purpose = Process Understanding
    - Variations in Transects = Greater Range of Process Understanding
  - **Focus Area**
    - **Water Table Mapping** = Combining Transect Empirical Data To Define General Nature of GW/SW Gradients and "Zones" Where "Upwelling" Takes Place
      - Zones Fluctuate Spatially Over Space and Time
      - Definition of Key Ranges for Zone Delineation
    - Groundwater Modeling (MODFLOW) = One Select Focus Area (FA-128 (Slough 8A)) - To Help Define Spatial Effects of Hydrologic Boundary Conditions On Transient Hydrologic GW/SW Interactions

Study 7.5 Analysis Steps – “Upwelling”

- **Scales and Methods** =
  - Transects
  - **Focus Area**
    - **Water Table Mapping**
      - Development of Point Maps For “**Discrete**” Time Periods
      - Use Of Other Information, Such As Rising/Falling Conditions, TIR Imagery, Open Lead Mapping, Aerial Photographs, Flow Routing Model Surface Water Profile (Stage) Information
      - Development of Groundwater and Surface-Water Contours
      - Definition of Upwelling Zones
      - Definition of Other Factors to Help Define Types of Groundwater Conditions (Ranges?) Within Zones (“Binary Approach”)

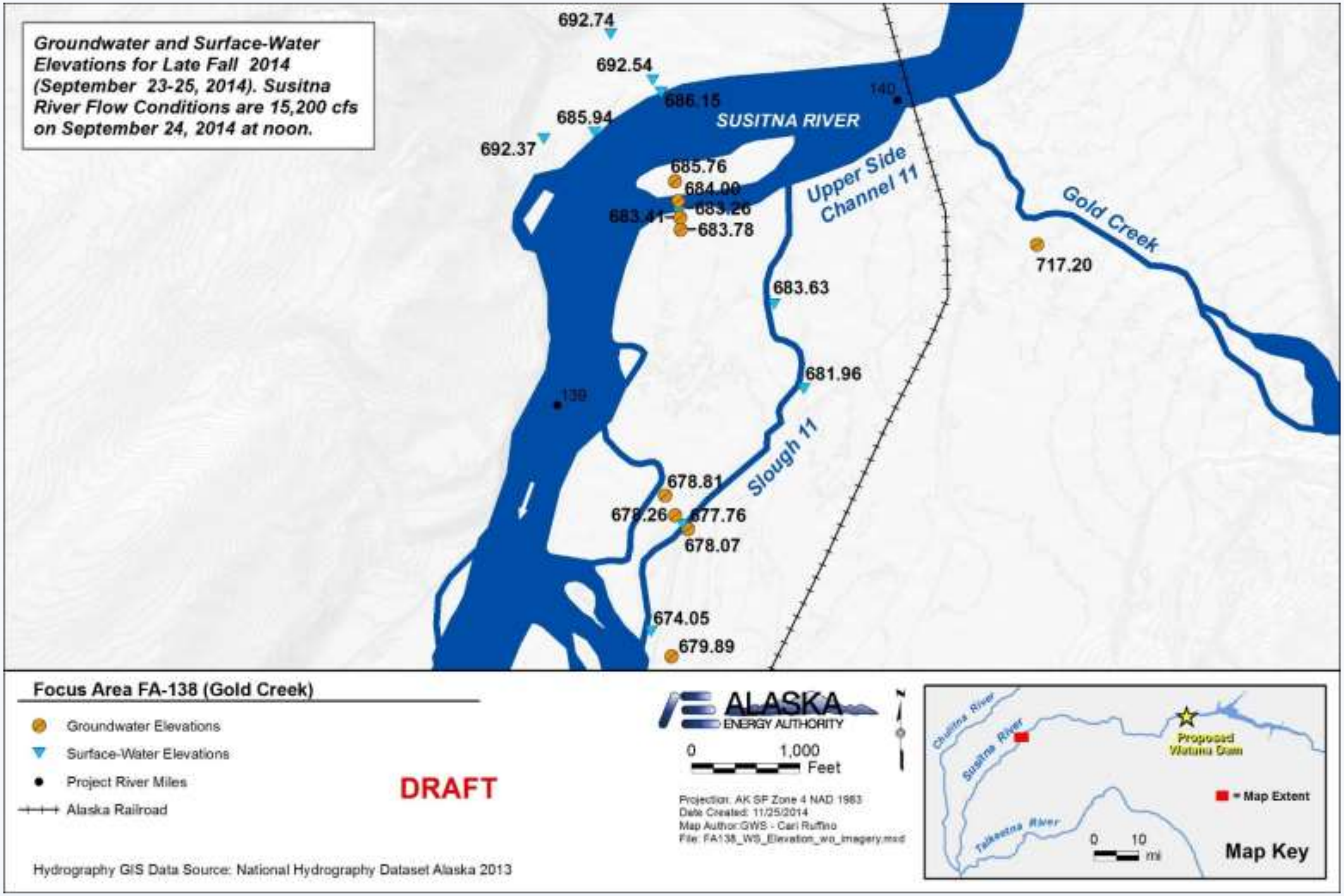
Study 7.5 Analysis Steps – “Upwelling”

- **Scales and Methods** =
  - Transects
  - **Focus Area**
    - **Water Table Mapping**
      - **Development of Point Maps For “Discrete” Time Periods**
        - Groundwater Elevations, Surface-Water Elevations
        - Aerial Photographs, Time-Lapse Images, Water Level Plots for Defining Overall Hydrology Conditions
        - River Stage Elevation Profiles from 1-D Flow Routing Models (Both Ice-Cover and Ice-Free Depending on Timeframe of Map)
        - Miscellaneous Elevations from combination of Aerial and Time-Lapse Images and DEM Information
        - Elevations Posted in ArcMap 10+

Study 7.5 Analysis Steps – "Upwelling"

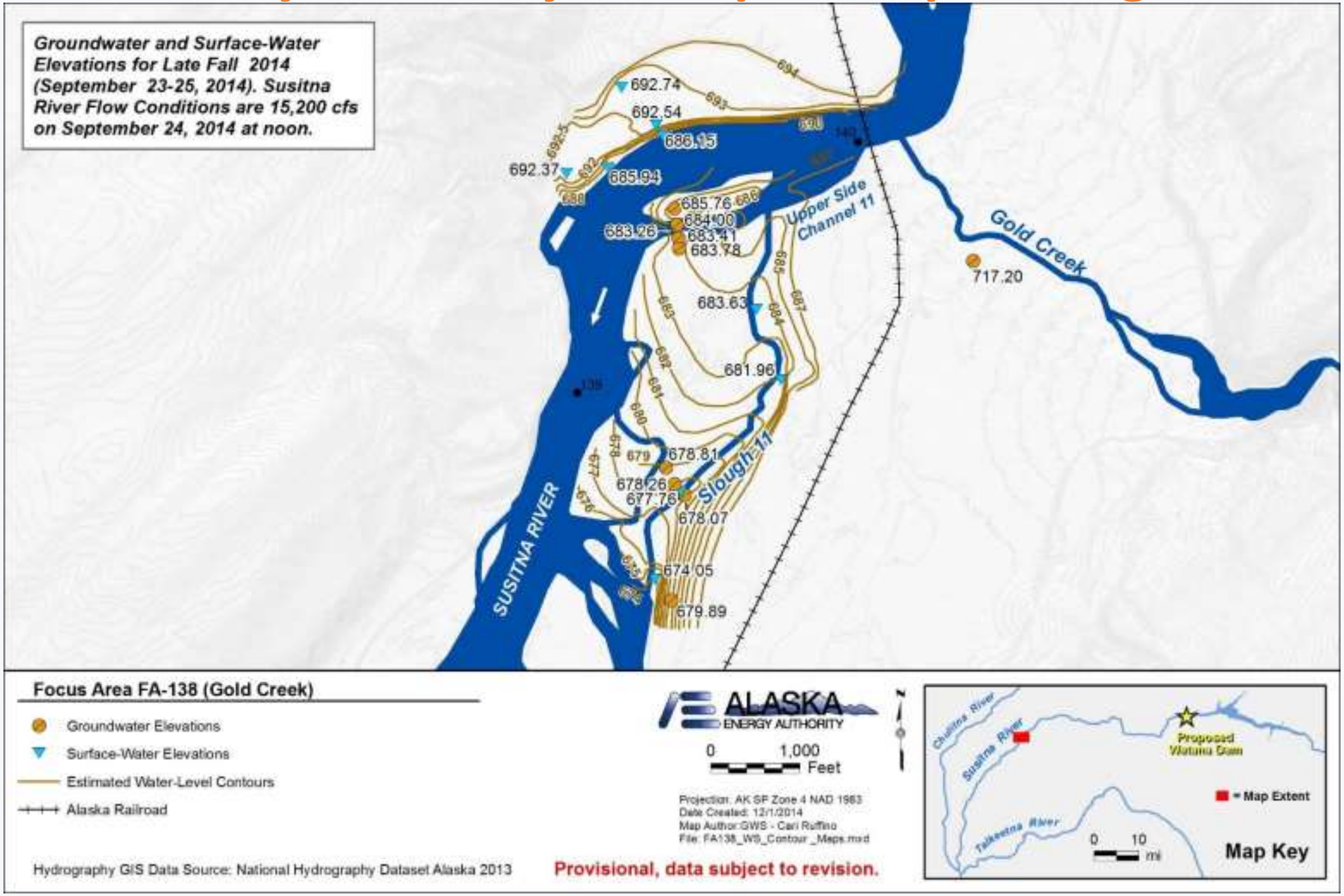
- **Scales and Methods** =
  - Transects
  - **Focus Area**
    - **Water Table Mapping**
      - **Development of Contour Lines (Water Table Surface) For "Discrete" Time Periods**
        - Rising and Falling Stage Information Used To Determine Relationship of Groundwater Contours to Surface-Water Features
        - Flowline May Be Shown, When Needed
        - Upwelling Boundaries Defined From Above Information
        - GIS data (shapefile) for each FA with polygons showing areas of upwelling in ArcGIS 10.x.– serves as input into fish habitat – flow models

Study 7.5 Analysis Steps – "Upwelling"



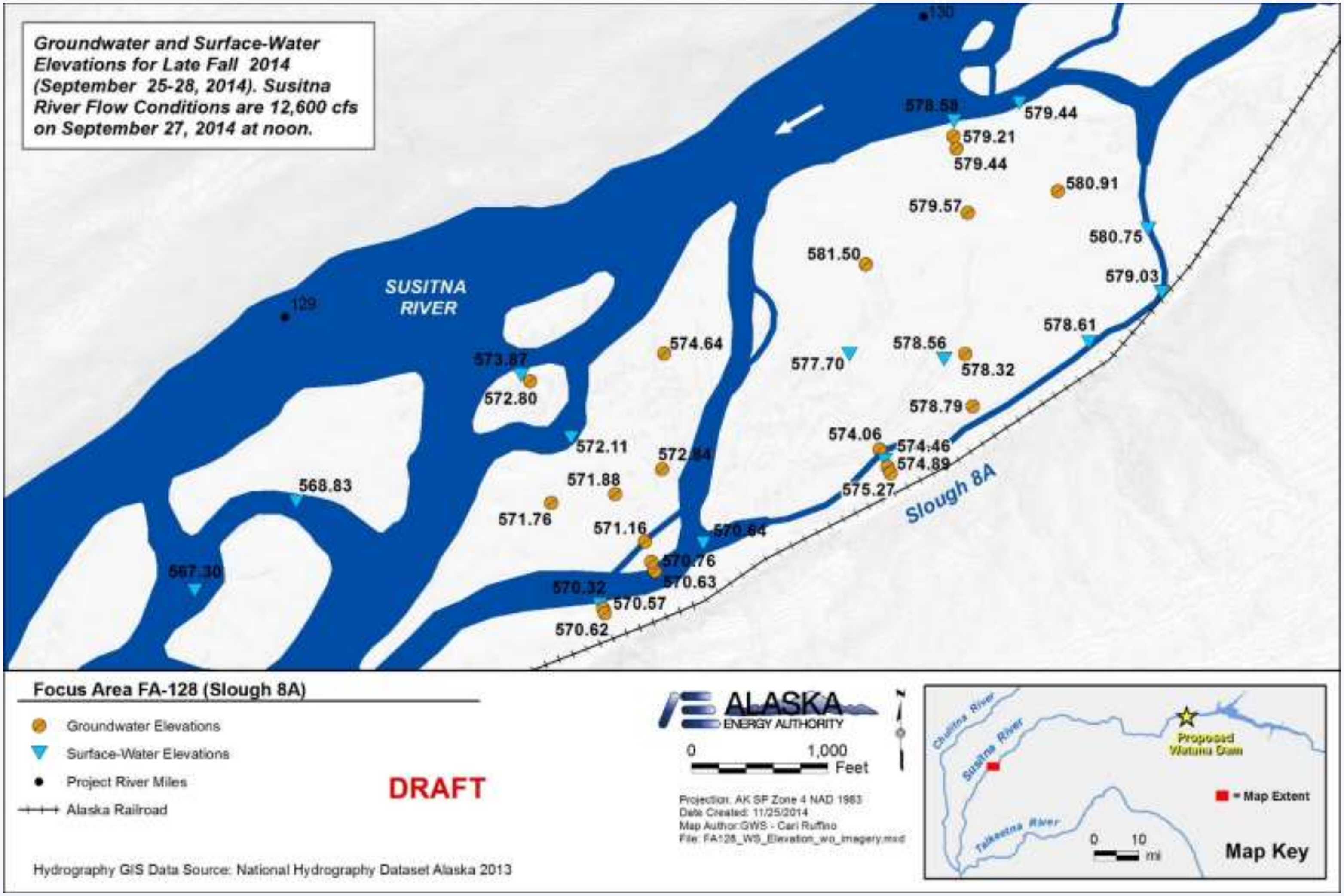
Example Sept/Oct 2014 Groundwater Elevations and Surface-Water Stage Point Maps

Study 7.5 Analysis Steps – "Upwelling"



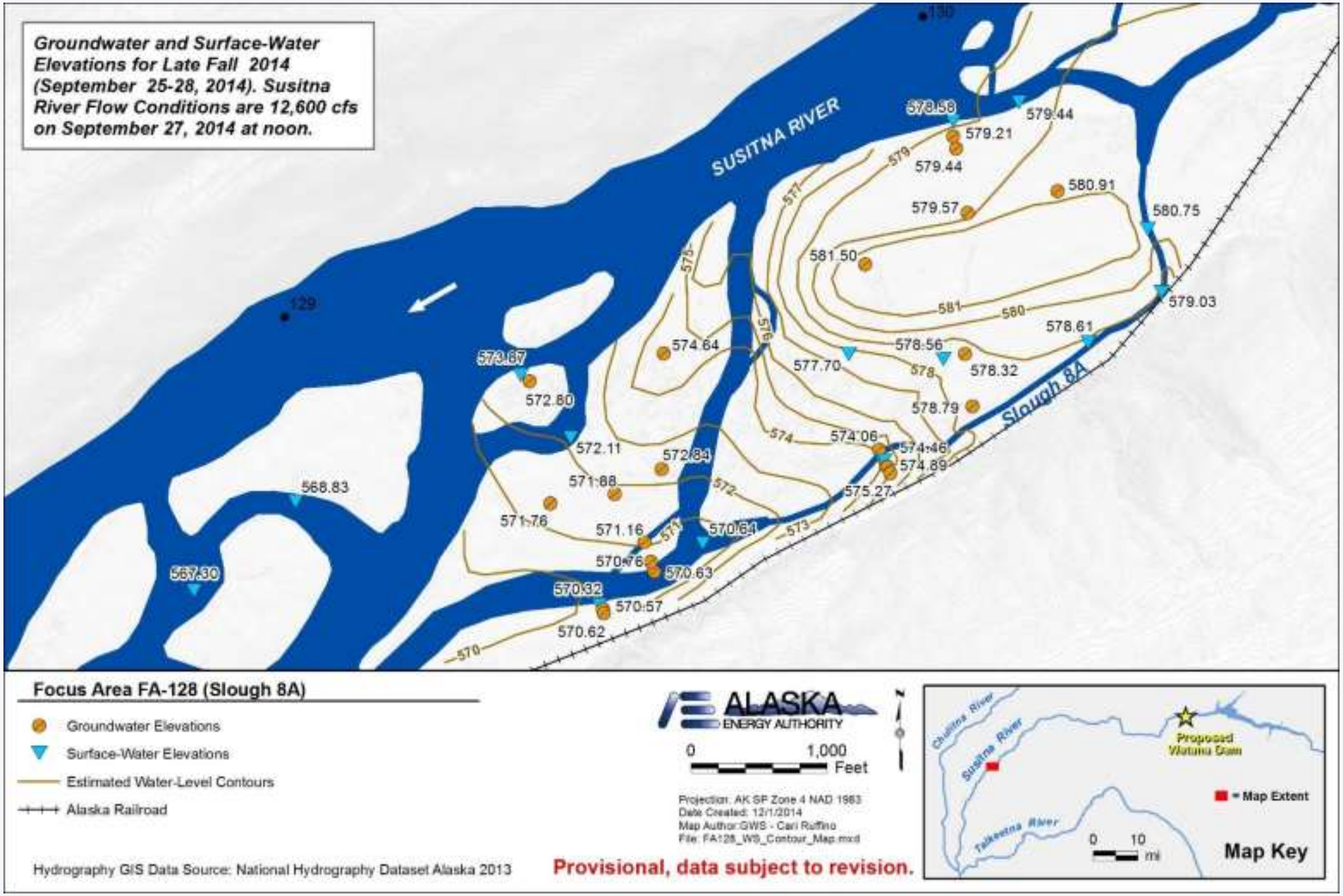
Example Sept/Oct 2014 Groundwater Water Table Contour Maps – FA-138 (Gold Creek)

Study 7.5 Analysis Steps – “Upwelling”



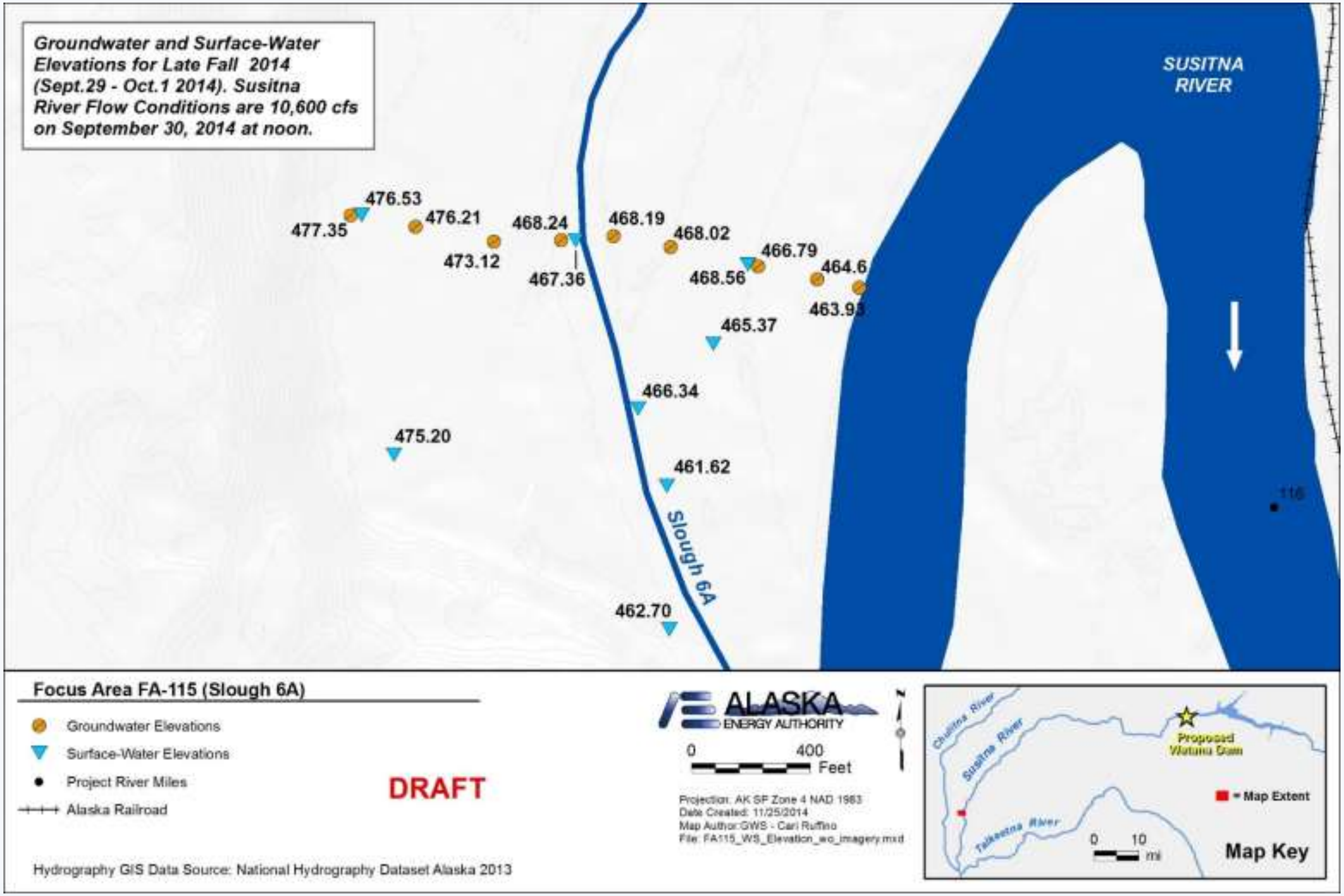
Example Sept/Oct 2014 Groundwater Elevations and Surface-Water Stage Point Maps

Study 7.5 Analysis Steps – "Upwelling"



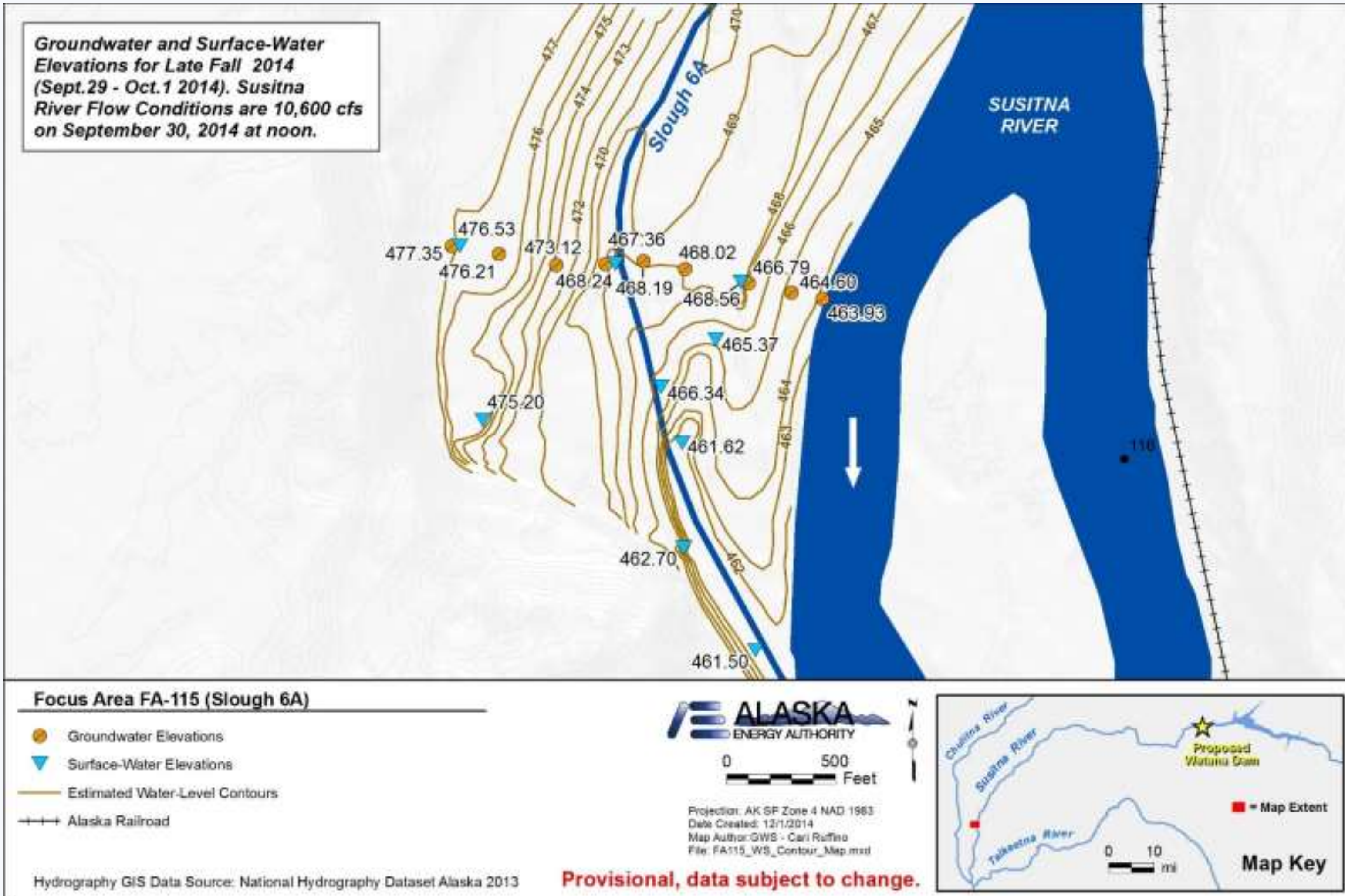
Example Sept/Oct 2014 Groundwater Water Table Contour Maps – FA-128 (Slough 8A)

Study 7.5 Analysis Steps – "Upwelling"



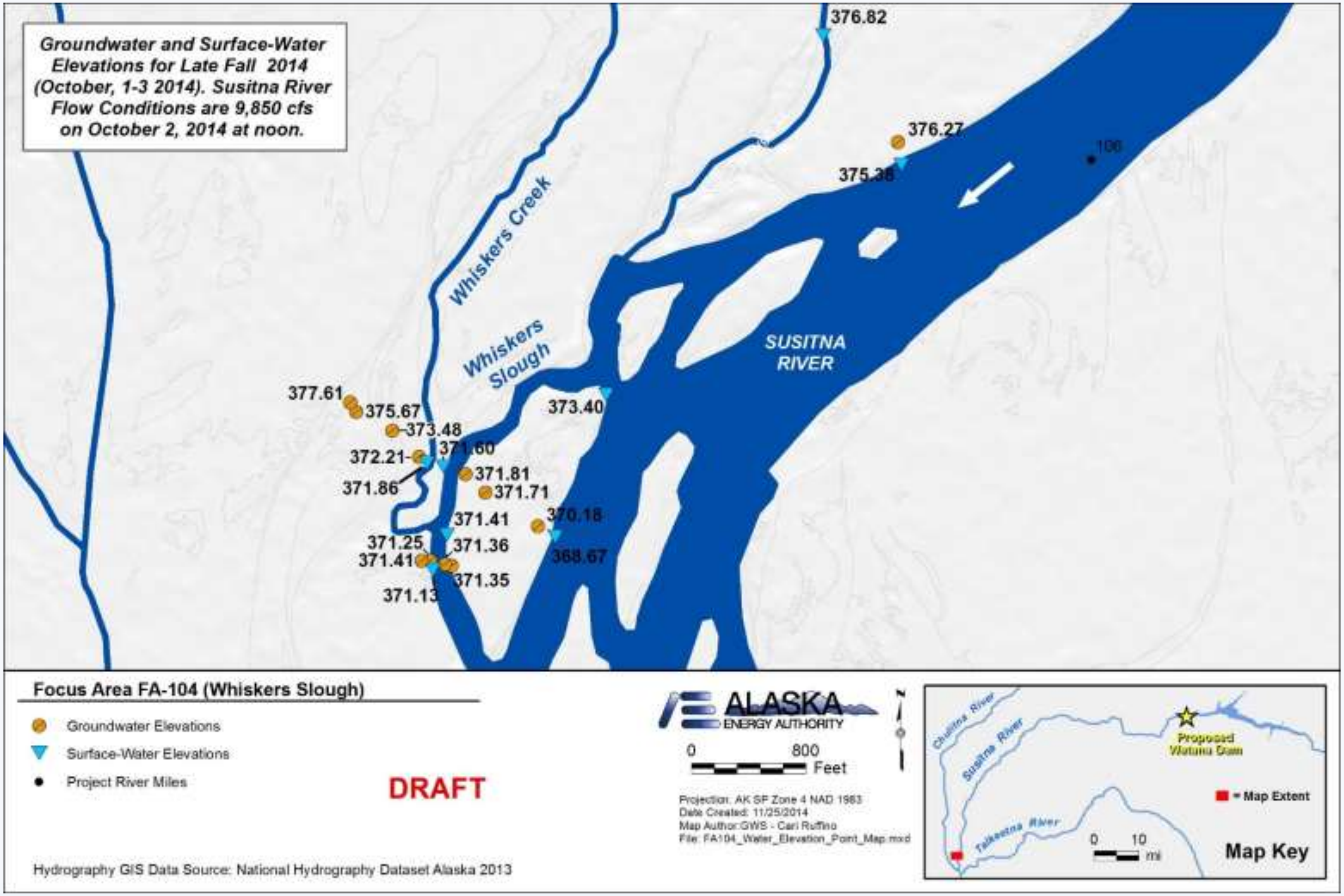
Example Sept/Oct 2014 Groundwater Elevations and Surface-Water Stage Point Maps

Study 7.5 Analysis Steps – "Upwelling"



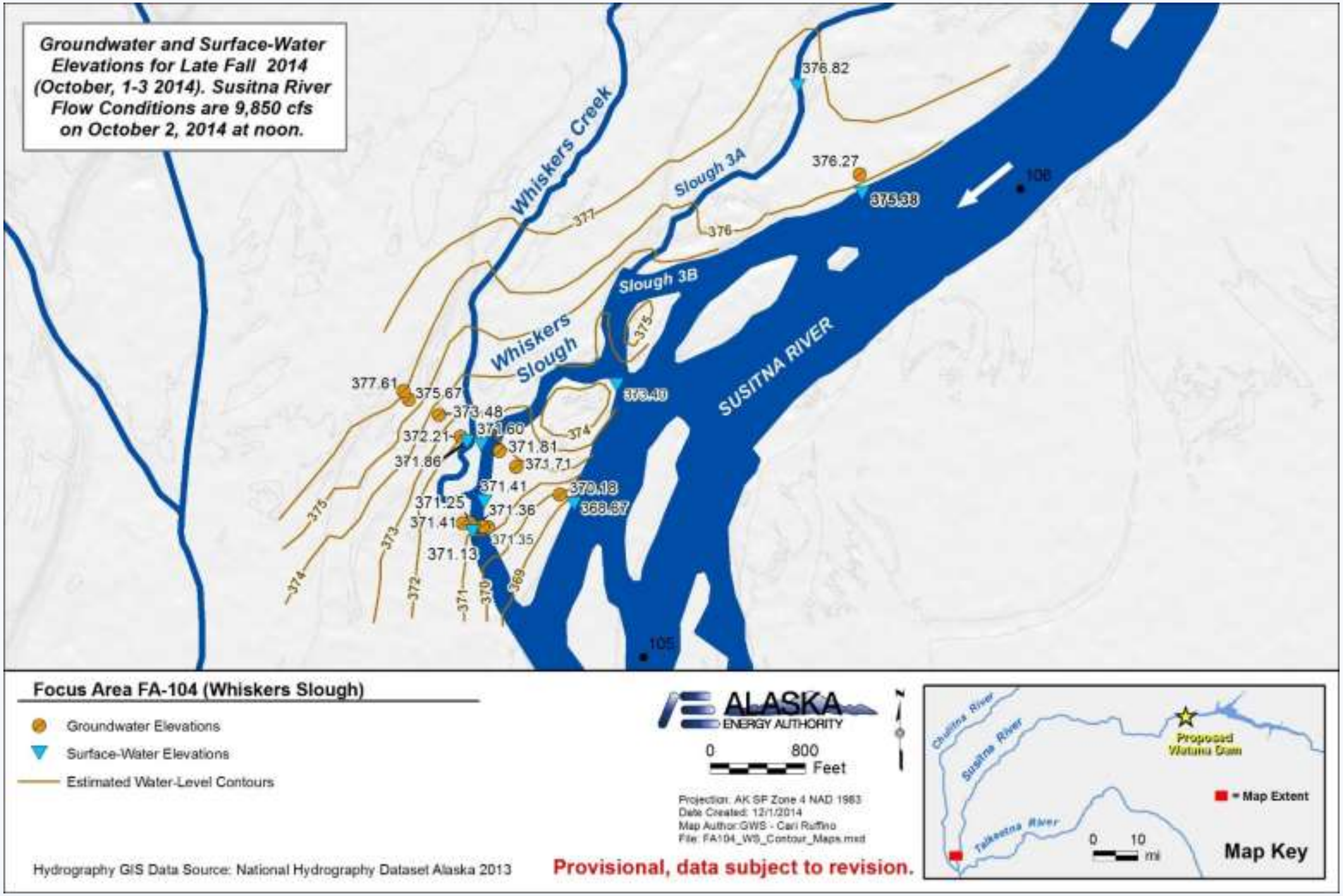
Example Sept/Oct 2014 Groundwater Water Table Contour Maps – FA-115 (Slough 6A)

Study 7.5 Analysis Steps – "Upwelling"



Example Sept/Oct 2014 Groundwater Elevations and Surface-Water Stage Point Maps

Study 7.5 Analysis Steps – “Upwelling”



Example Sept/Oct 2014 Groundwater Water Table Contour Maps – FA-104 (Whiskers Slough)

Study 7.5 Analysis Steps – "Upwelling"

Example Water Table Maps from 1980s

Study 7.5 Analysis Steps – “Upwelling”

Example Upwelling Zone Maps – Only For Illustration

Study 7.5 Analysis Steps – "Upwelling" – GIS Polygons for Fish Habitat-Flow Models

Example Upwelling Zone Maps, Different Flows – Only For Illustration

Study 7.5 Analysis Steps – "Upwelling" – GIS Polygons for Fish Habitat-Flow Models

Example Upwelling Zone Maps, Different Flows – Only For Illustration

Study 7.5 Analysis Steps – "Upwelling"

- **Field Verification Methods** =
  - TIR Imagery When Time Periods and Hydrologic Gradients Match
  - Open Lead Mapping When Time Period and Hydrologic Gradients Match
  - Miscellaneous Vertical Head Indicator (VHI) Information
    - Intended Only for Relative Information (positive/negative)
  - Field Measurements of Discharge Pairs (Differences) and Individual Discharge Measurements
  - VHG Measurement Transects at Key Locations
    - Sensors Left in Place in Stream Bed
    - Aquatic Transects
    - Estimated Boundaries Between Upwelling and Downwelling Areas
  - Vertical Flux Modeling at Thermal Profile Locations in Aquatic Transects (USGS, 1DTempPro Modeling), Aquatic Transects

Study 7.5 Analysis Steps – "Verification Data Examples"

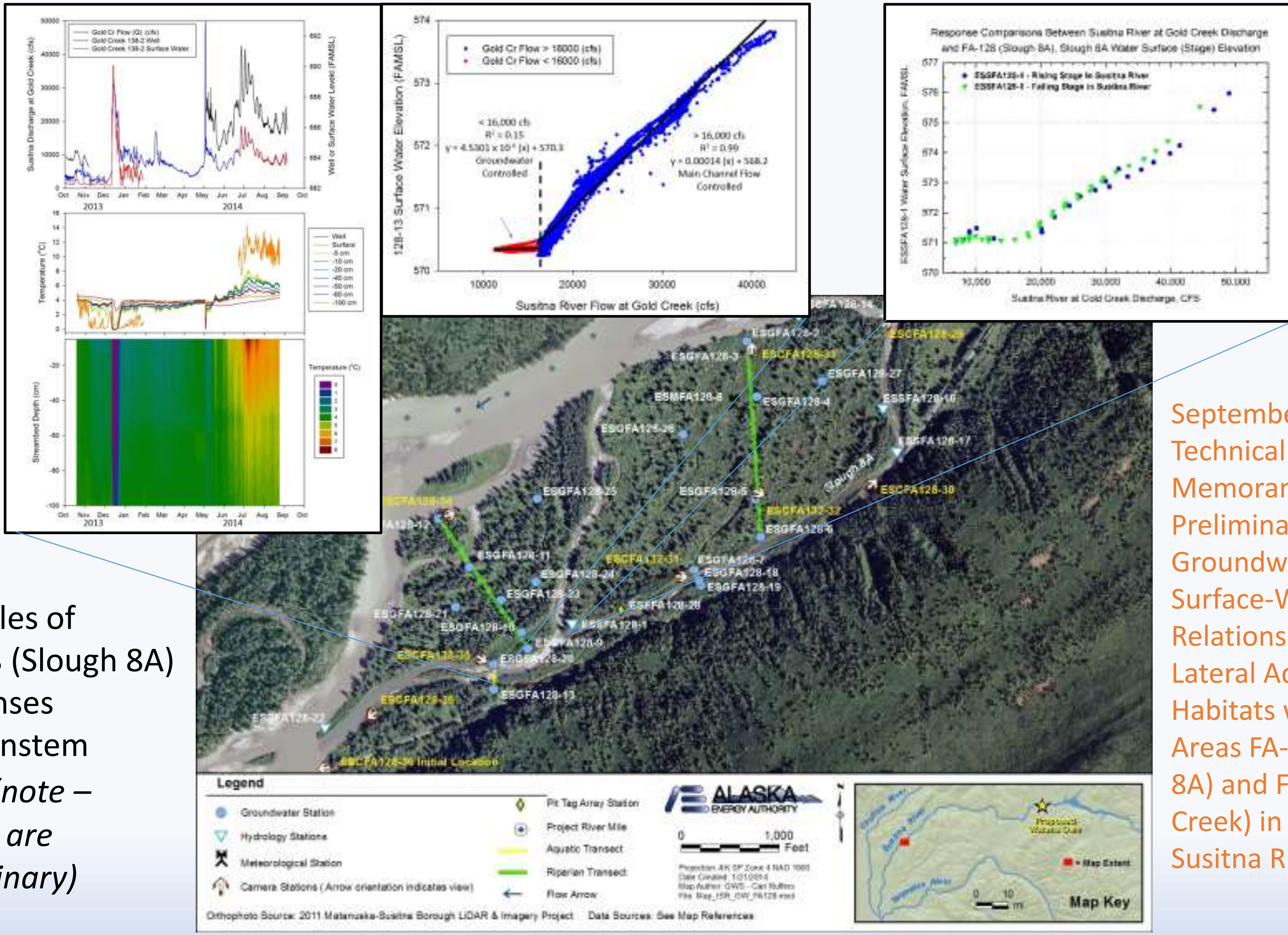
Questions and Discussion of Presented Material

Break

Study 7.5 Analysis Steps – Post ISR Materials

- **Aquatic Technical Memorandum**
  - Preliminary Groundwater and Surface-Water Relationships in Lateral Aquatic Habitats within Focus Areas FA-128 (Slough 8A) and FA-138 (Gold Creek) in the Middle Susitna River
- **Riparian Technical Memorandum**
  - Groundwater and Surface-Water Relationships in Support of Riparian Vegetation Modeling

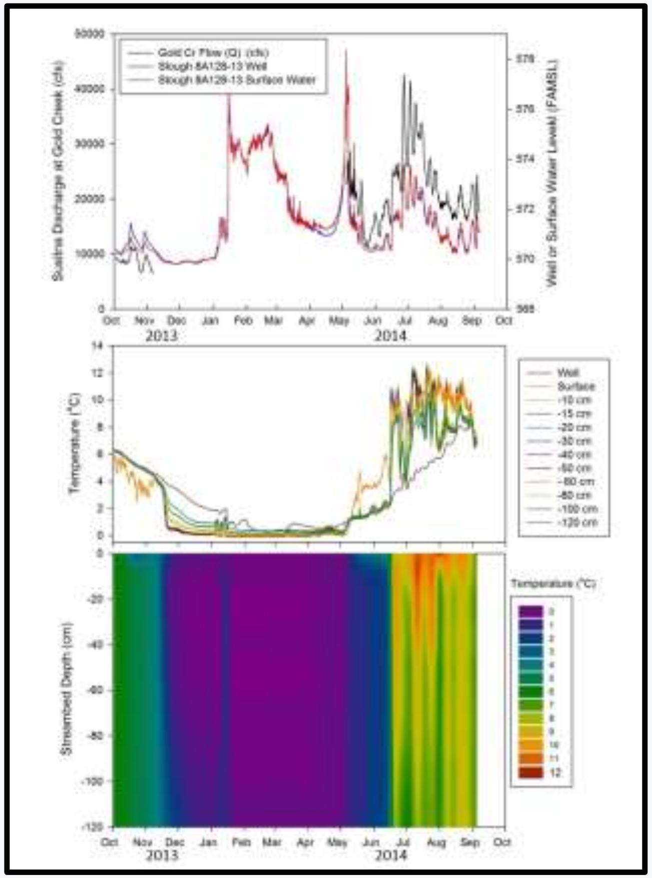
Study 7.5 Transect Scale – Process Understanding Examples



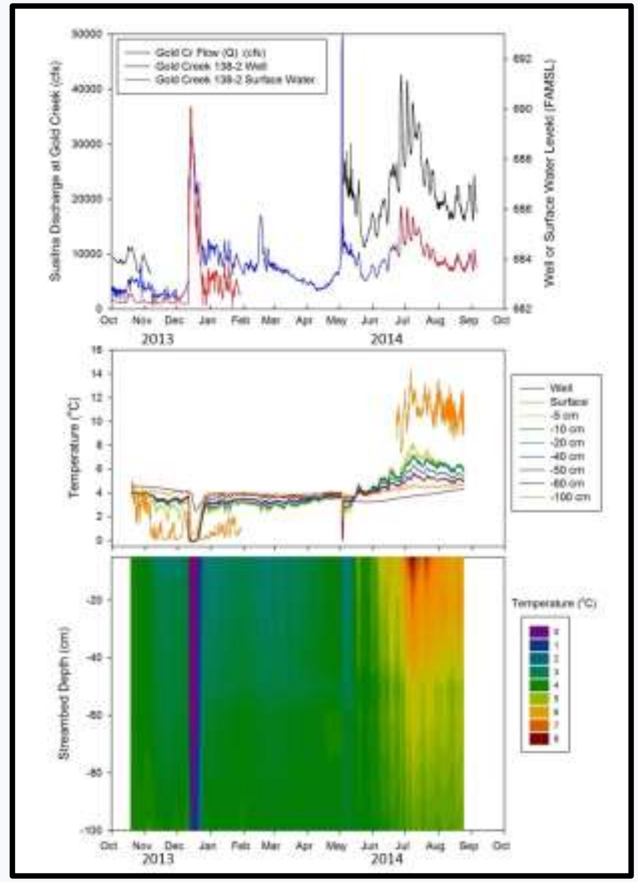
Examples of FA-128 (Slough 8A) Responses To Mainstem Flow *(note – results are preliminary)*

September 2014 Technical Memorandum - Preliminary Groundwater and Surface-Water Relationships in Lateral Aquatic Habitats within Focus Areas FA-128 (Slough 8A) and FA-138 (Gold Creek) in the Middle Susitna River.

Study 7.5 Transect Scale – Process Understanding Examples



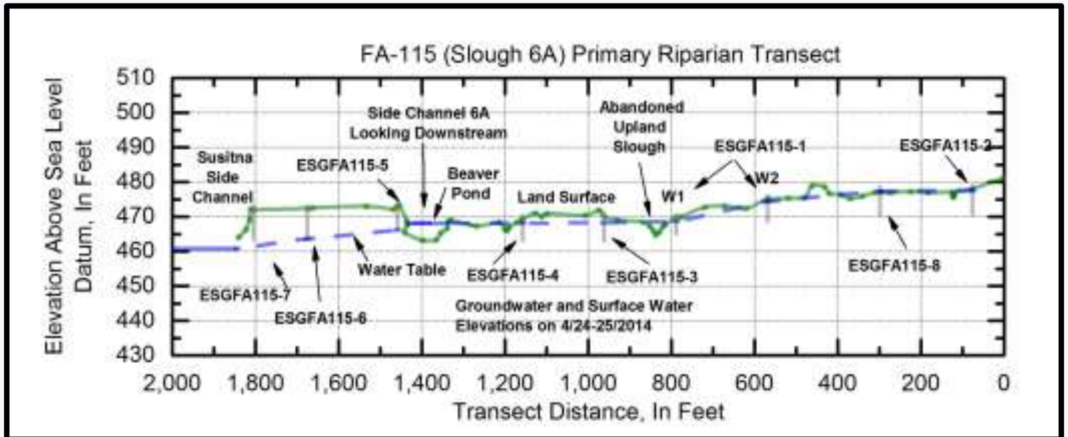
FA-128 (Slough 8A)
Middle Side Channel 8A
Lower Aquatic Transect
Downwelling Example



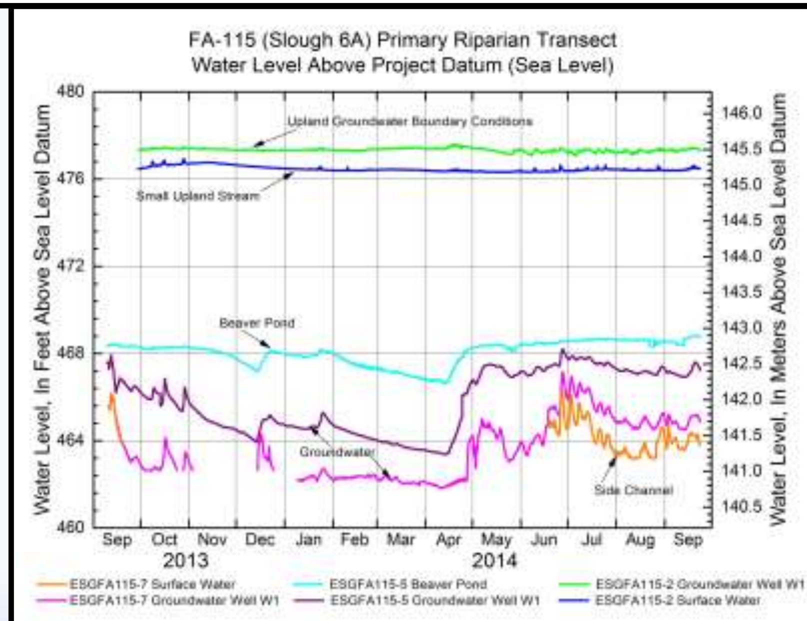
FA-138 (Gold Creek)
Upper Side Channel 11
Upper Aquatic Transect
Upwelling Example

September 2014 Technical Memorandum - Preliminary Groundwater and Surface-Water Relationships in Lateral Aquatic Habitats within Focus Areas FA-128 (Slough 8A) and FA-138 (Gold Creek) in the Middle Susitna River.

Study 7.5 Transect/Focus Area Scale – Process Understanding



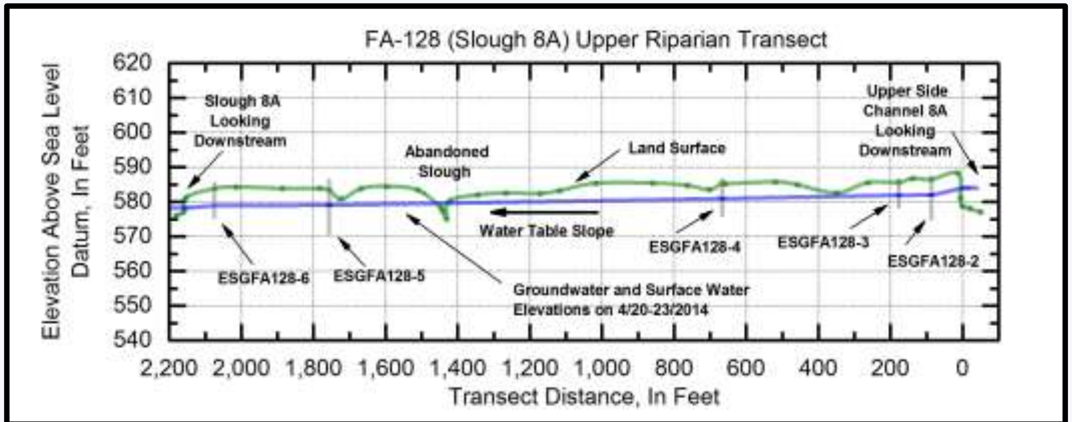
FA-115 (Slough 6A)
Primary Riparian Transect
Lateral Hydraulic Gradients



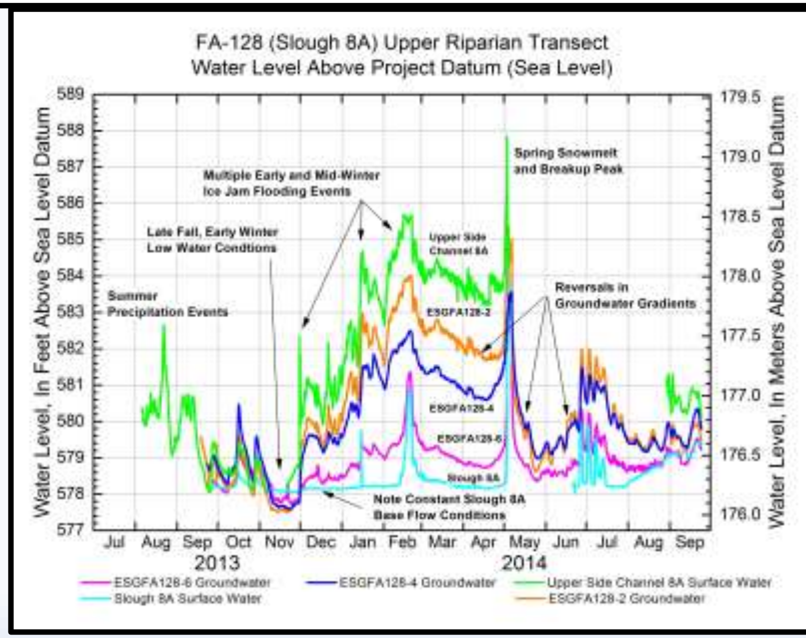
September 2014 Technical Memorandum - Groundwater and Surface-Water Relationships in Support of Riparian Vegetation Modeling

FA-115 (Slough 6A)
Primary Riparian Transect
Seasonal Water-Level Variation

Study 7.5 Transect/Focus Area Scale – Process Understanding



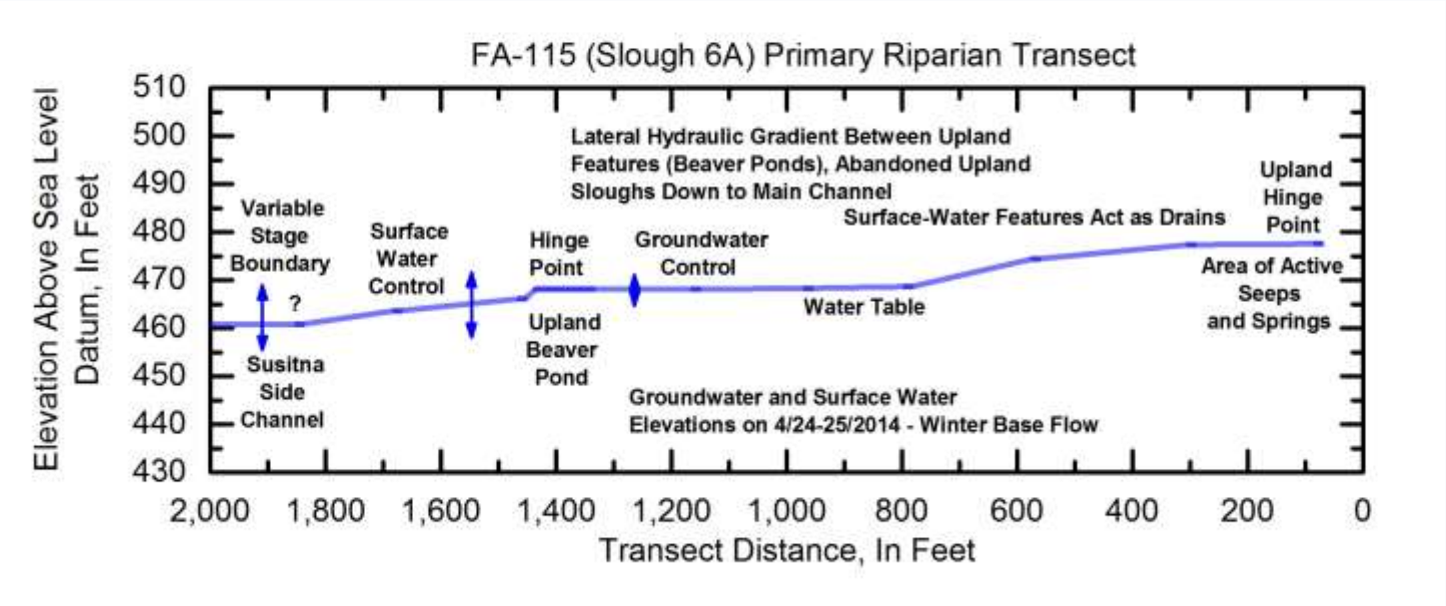
FA-128 (Slough 8A)
Upper Riparian Transect
Lateral Hydraulic Gradients



- September 2014 Technical Memorandum - Groundwater and Surface-Water Relationships in Support of Riparian Vegetation Modeling

FA-128 (Slough 8A)
Upper Riparian Transect
Seasonal Water-Level Variation

Study 7.5 Transect/Focus Area Scale – Process Understanding



An Example Transect Definition of Processes Defining Lateral Hydraulic Gradients, A Hinge Point, and Upland Versus Riverine Dominated Groundwater Conditions – FA-115 (Slough 6A).

September 2014 Technical Memorandum - Groundwater and Surface-Water Relationships in Support of Riparian Vegetation Modeling

Study 7.5 Analysis Steps – “Scaling Up”

- **Scales and Methods** =
  - Focus Area and Lower-River Transect Scale
  - **Focus Area**
    - Development of Process Understanding, Supporting Data, Understanding of Uncertainty
    - Primary and Test Transects
    - Range of Focus Area Conditions = Representative Variation of Riverine to Upland Dominated Transects
    - “Understanding Needed” to Interpret Available Data Between Focus Areas at River Segment Scale
  - River Segment Scale
    - **For IFS Fish and Aquatics**: Scaling Up is Based on Habitat Model Extrapolation (TBD); Habitat Model Incorporates Groundwater Upwelling Within HSC

Study 7.5 Analysis Steps – Riparian "Scaling Up"

- **Scales and Methods** =
  - Focus Area and Lower-River Transect Scale
  - **Focus Area Scale - Riparian**
    - Information Layers
      - Floodplain Water Body Hydrography
        - Beaver Ponds, Other Ponds
        - Sloughs, Streams, Springs, Seeps
      - Groundwater Hydrography
        - Water Table Maps – Focus Areas, Specific Conditions
  - River Segment Scale

Study 7.5 Analysis Steps – Riparian "Scaling Up"

- **Scales and Methods** =
  - Focus Area and Lower-River Transect Scale
  - Focus Area Scale
  - **River Segment Scale - Riparian**
    - GIS Approach
    - Base Land Surface – DEM
    - Hydrologic Landscapes
    - Ice-Free and Ice Flow Routing Model Stage Simulations
    - Information Layers
      - Aquatic Habitat Types
      - Riparian Vegetation Mapping
        - Subsets of Species Indicating Shallow Groundwater
        - Subsets of Species Indicating Deep Groundwater
      - Hydrography

Study 7.5 Analysis Steps – Riparian “Scaling Up”

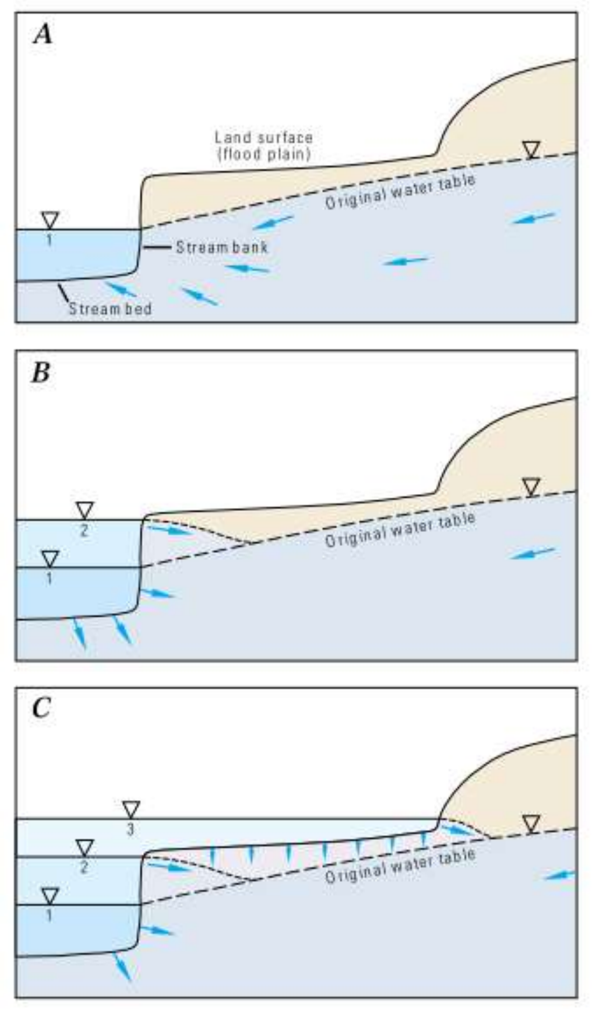
- **Scales and Methods** =
  - Focus Area and Lower-River Transect Scale
  - Focus Area Scale
  - **River Segment Scale - Riparian**
    - Information Layers
      - Hydrography
        - Beaver Ponds, Other Ponds
        - Sloughs, Streams, Springs, Seeps
        - Water Table Maps – Focus Areas, Specific Conditions
      - Geohydrologic Domains
      - Geology
        - Geomorphology Mapping
        - Watershed Scale Geology Mapping
      - Additional Floodplain Water Body/River Stage Measurements

Study 7.5 Analysis Steps – Riparian "Scaling Up"

- **Scales and Methods** =
  - Focus Area and Lower-River Transect Scale
  - Focus Area
  - **River Segment Scale - Riparian**
    - Process
      - Using Prior Features and Information
      - Define Upland Groundwater Elevations
      - Define River Stage Conditions
      - Define Lateral Gradients
      - Define "Hinge Line" Between Upland Dominated And Riverine Dominated Groundwater Conditions
      - Estimate Areas Where Hydraulic Gradient Is Impacted By Changing River Stage Conditions (Project Operations)
      - Evaluate Changes to Habitat (Aquatic, Riparian) In Zones of Potential Impact

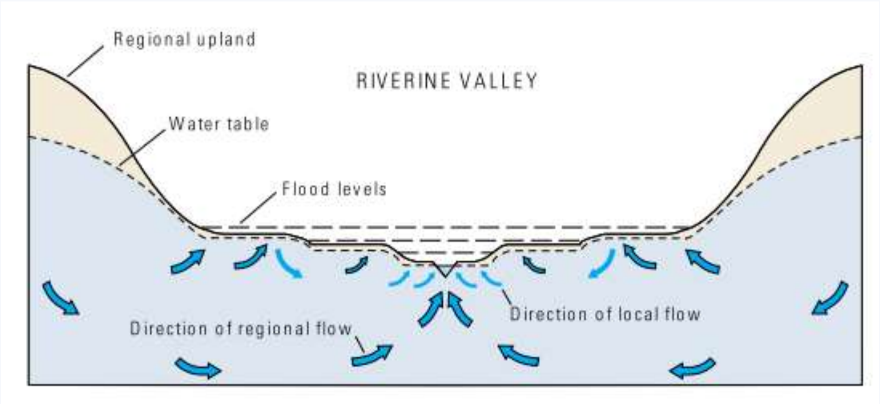
Following Slides Are Only Place Holders For Potential Use in Discussions

Study 7.5 Analysis Steps – "Scaling Up" Examples



Riverine Terrain:

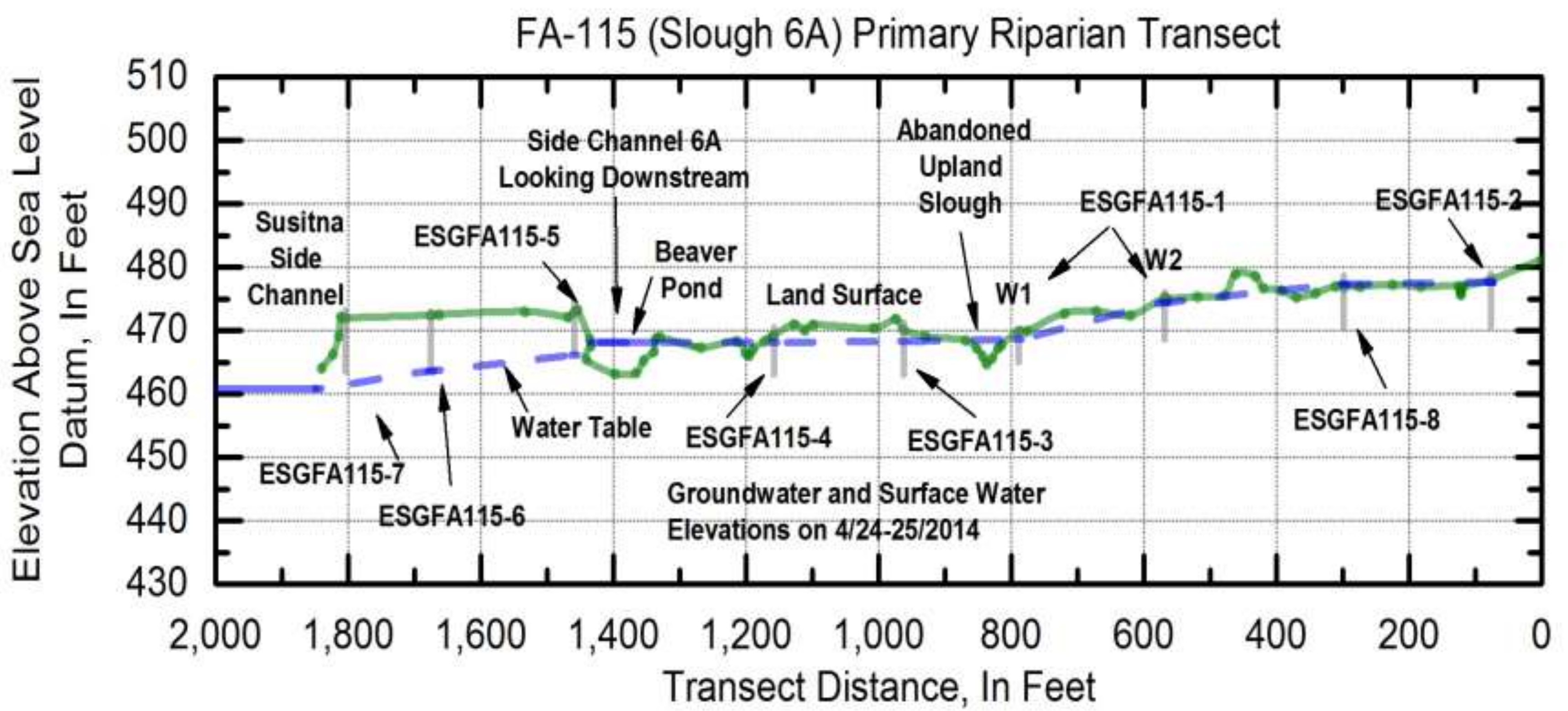
- **Regional vs. local scale flowpaths**
- **Flood waters → "Bank storage"**



Figures from Winter, 1998

Study 7.5 Analysis Steps – "Scaling Up" Examples

Study 7.5 Analysis Steps – "Scaling Up" Examples



Study 7.5 Analysis Steps – "Lateral Gradient" Examples

- FA-138 (Gold Creek)
- How Are Upland Sloughs and Wetlands Impacted By River Stage Levels?
- How Does this Vary Over The Annual Hydrologic Cycle?
- At What Scale are GW/SW Interactions Significant?
- Upland Wetland Hydrology Observations (Study Objective #6; RSP 8.6.3.6)

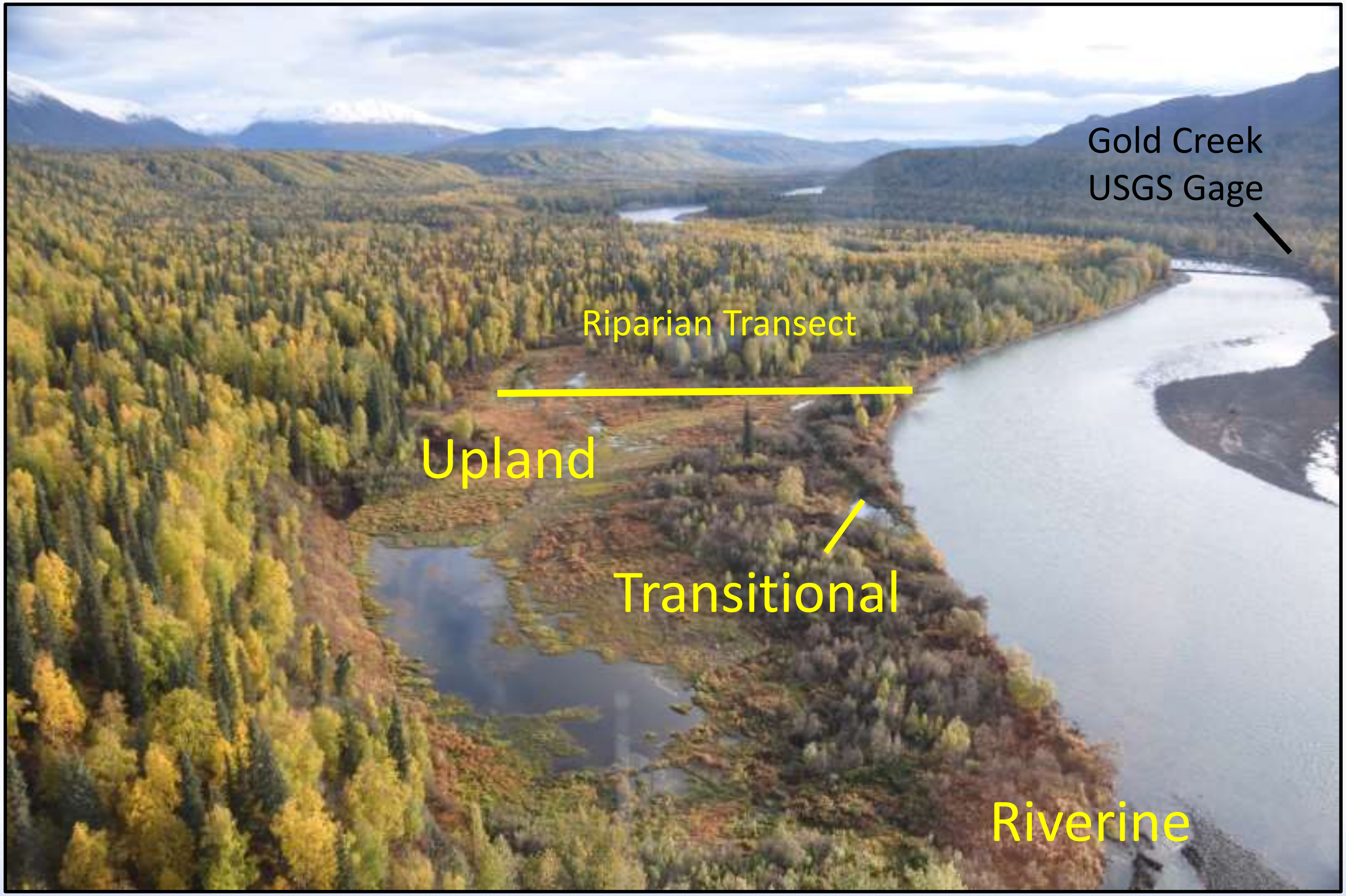
FA-138 (Gold Creek) Focus Area, Right Bank Upland Sloughs and Wetlands, during heavy rainfall and precipitation flood peak on the Susitna River, August 22, 2013

Study 7.5 Analysis Steps – "Lateral Gradient" Examples

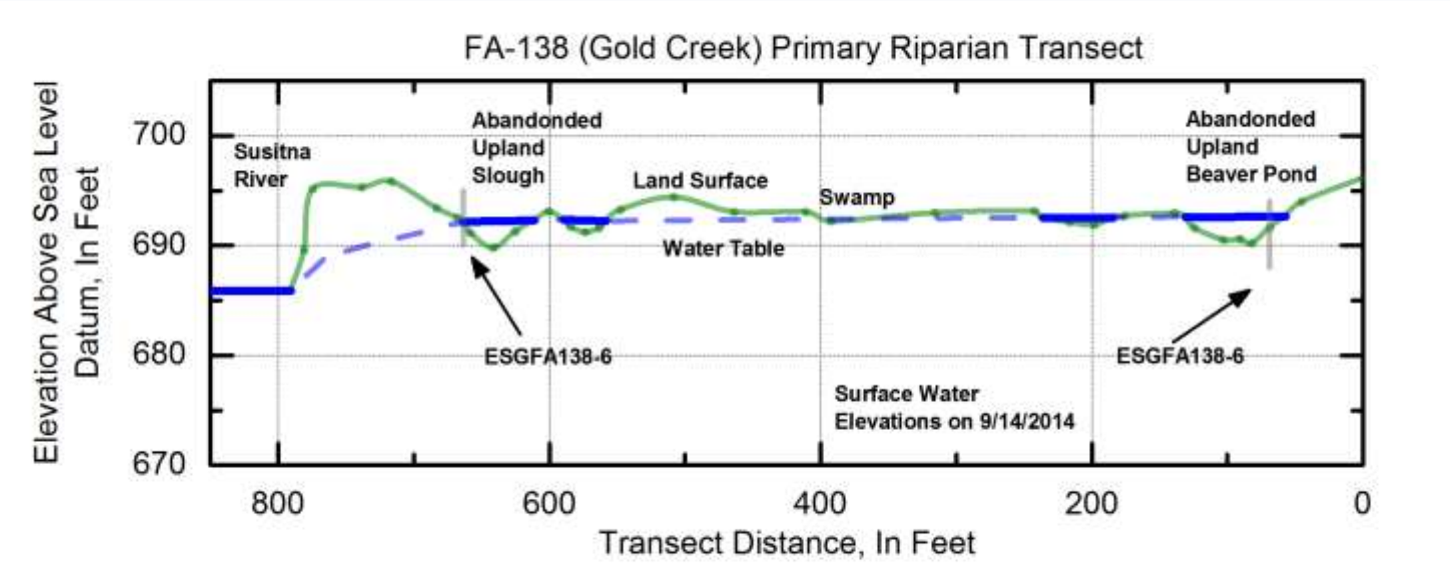
- Does Recharge From Groundwater Help Maintain Wetland Vegetation?
- What Winter Observations Help Understand This?
- What Snowmelt Transition Observations Help Understand This?

FA-138 (Gold Creek) Focus Area, Right Bank Upland abandoned beaver pond during periods of heavy rains, August 22, 2013

Study 7.5 Analysis Steps – "Lateral Gradient" Examples

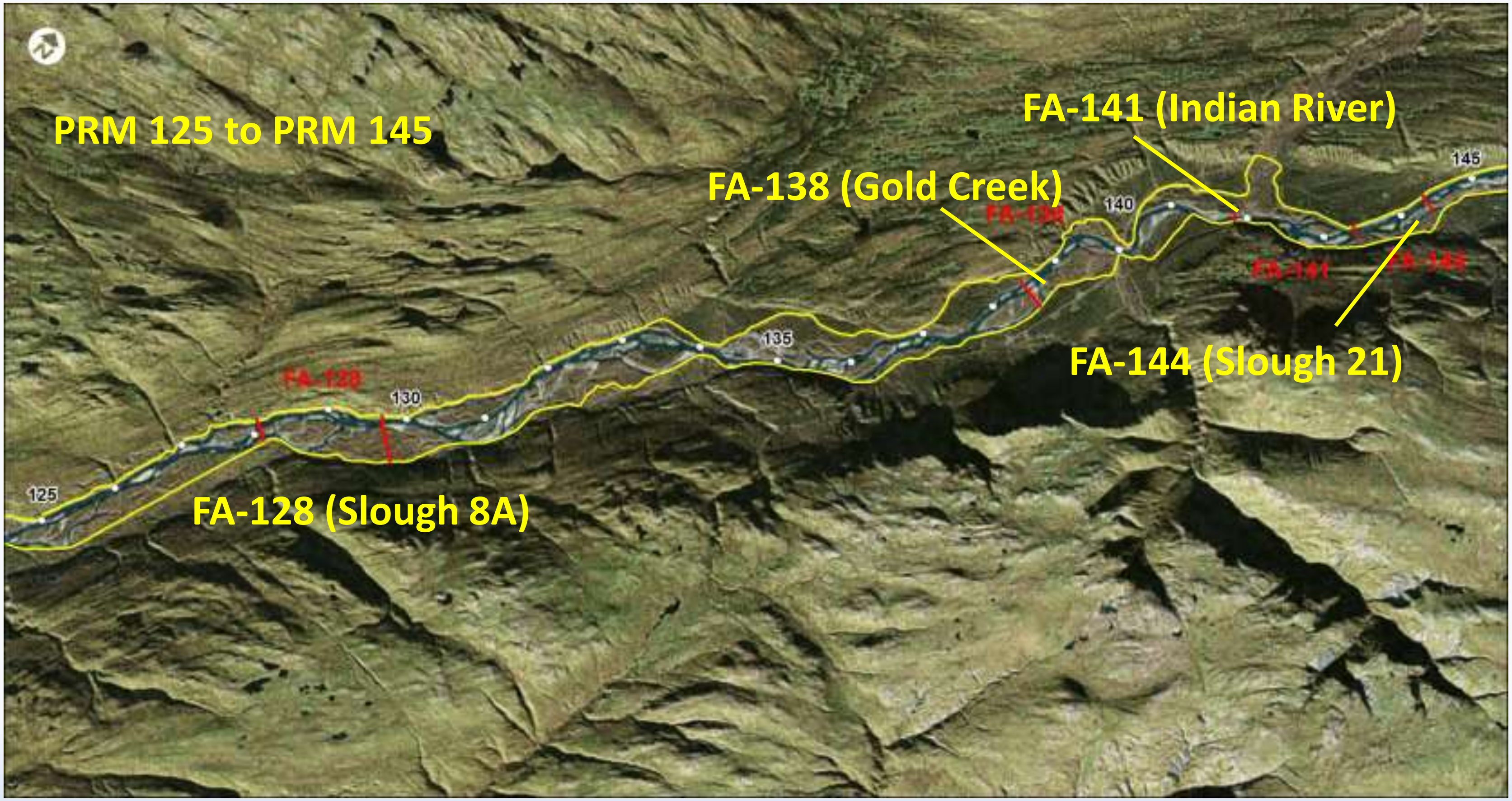


Study 7.5 Analysis Steps – “Lateral Gradient” Examples

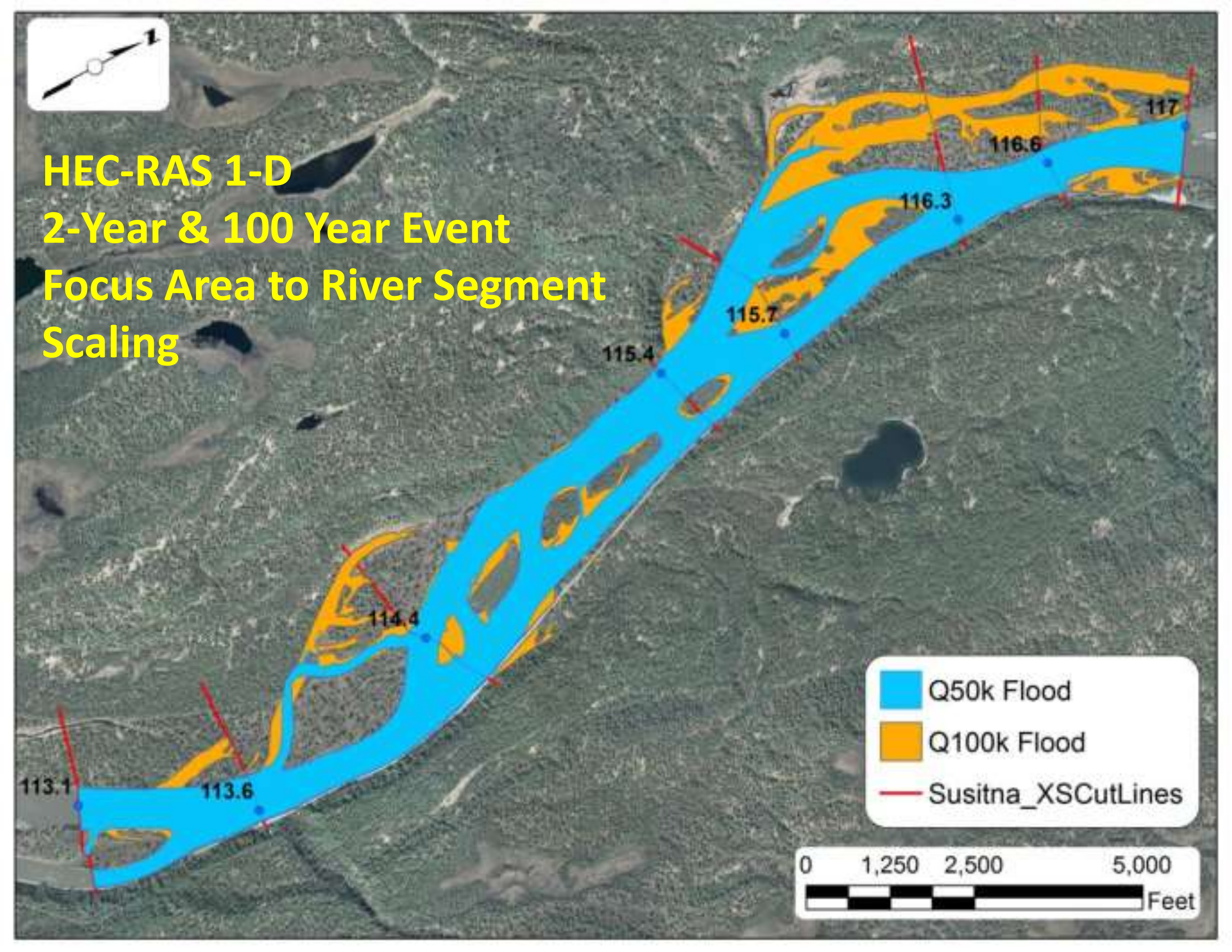


SUSITNA-WATANA HYDRO Clean, reliable energy for the next 100 years.

Study 7.5, 8.6 Analysis Steps – "Scaling Up From FA Reach to the River Segment"

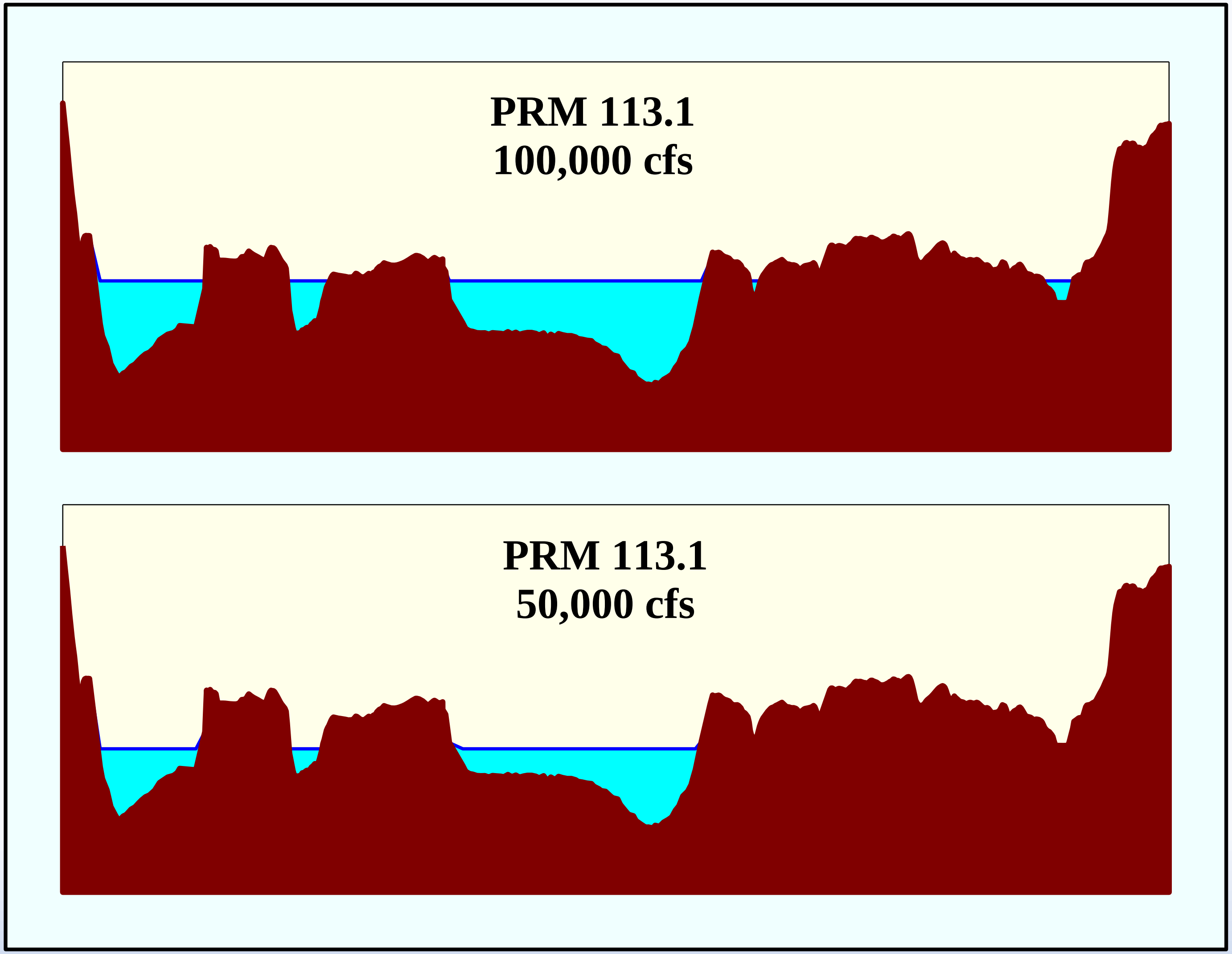


Study 7.5 Analysis Steps – "Scaling Up"
1D Flow Routing Modeling Examples

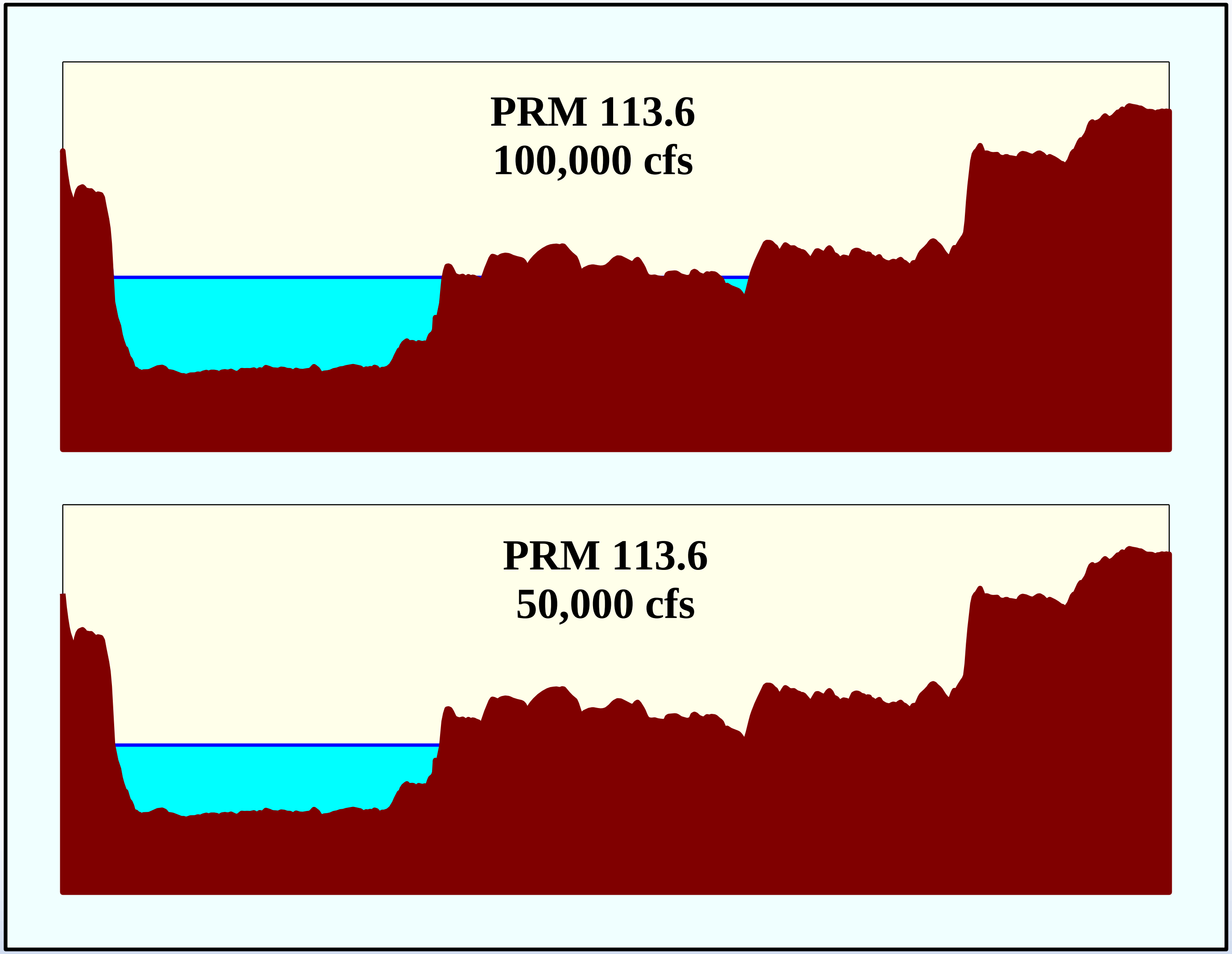


SUSITNA-WATANA HYDRO Clean, reliable energy for the next 100 years.

Study 7.5 Analysis Steps – "Scaling Up" 1D Flow Routing Modeling Examples



Study 7.5 Analysis Steps – "Scaling Up" 1D Flow Routing Modeling Examples



Study 7.5 Analysis Steps – "Scaling Up" Non-Focus Area Examples – PRM 123

Study 7.5 Analysis Steps – "Upwelling"

- **Scales** = Transect –> Focus Area –> River Segment
- **Timing** = Seasonal Approaches
  - Ice *Versus* Ice-Free = Three Winter Periods *Versus* Summer Period
- **Conditional** = Select Flow Conditions, Winter Conditions, Variations in Hydraulic Boundary (Stage) Conditions
- **Definitions** =
  - Groundwater Discharge = Flow to Surface = "Upwelling"
  - Groundwater Recharge = Flow from Surface = "Downwelling"
  - Hydraulic Gradient = Difference Between Water Elevations Over A Select Distance
  - Groundwater/Surface-Water (GW/SW) Interactions = The Pressure and Mass (Flux) Interactions Taking Place Between Surface-Water Systems and Groundwater
  - Hyporheic Zone = The Groundwater Zone Located at the Boundary Condition with Surface-Water Systems Where Active Mass (Flux) Exchange Occurs, Usually Related To Biogeochemical Interactions

Study 7.5 Analysis Steps – "Upwelling"