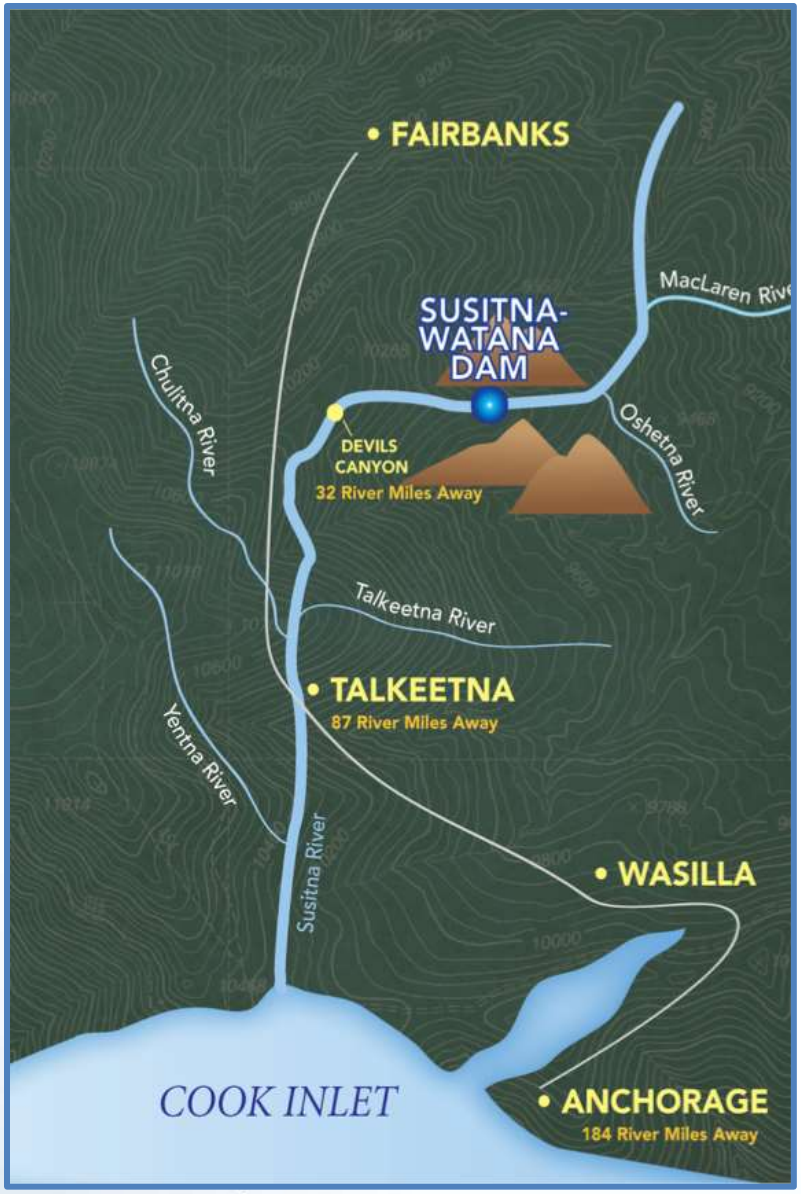


SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Technical Team Meeting

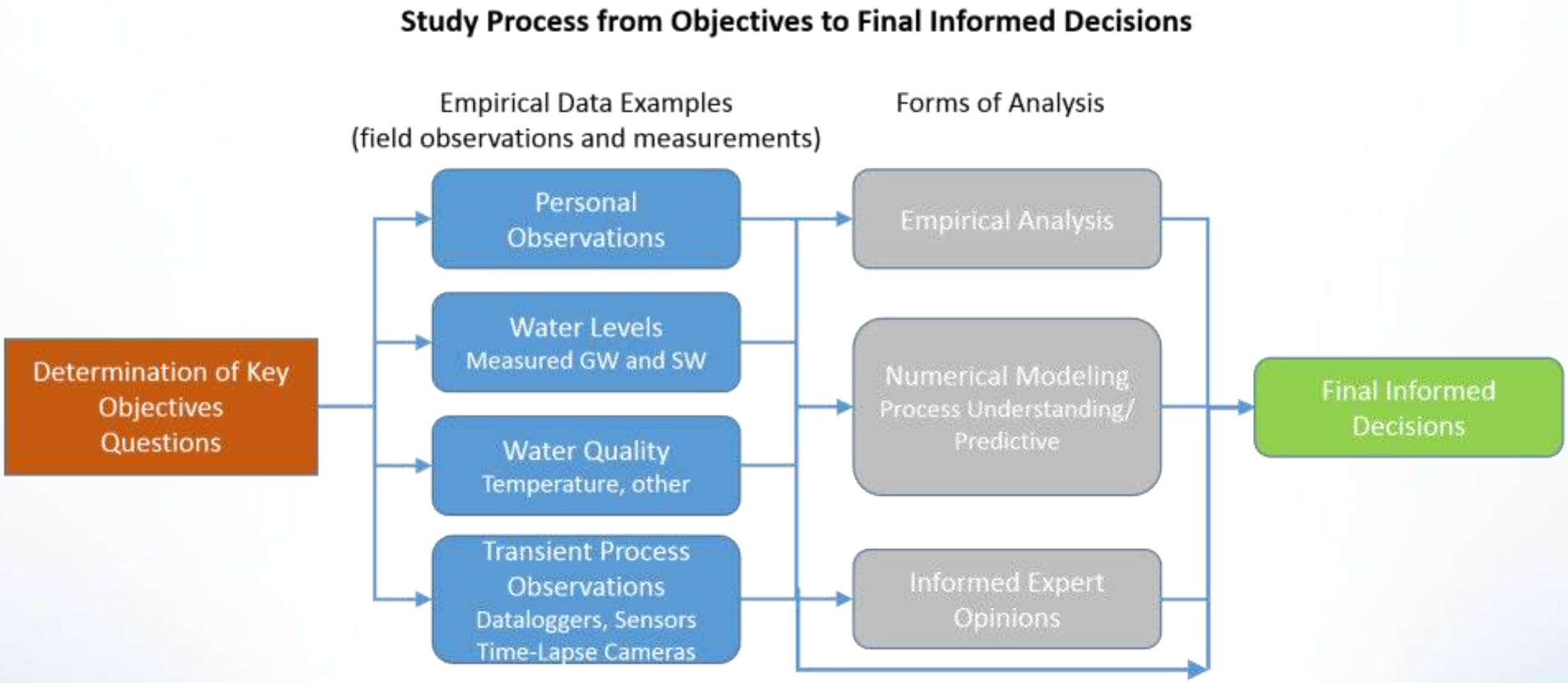
RIFS-TT: Riparian/Riverine Modeling

Hydrology/Groundwater: Empirical Studies and Modeling

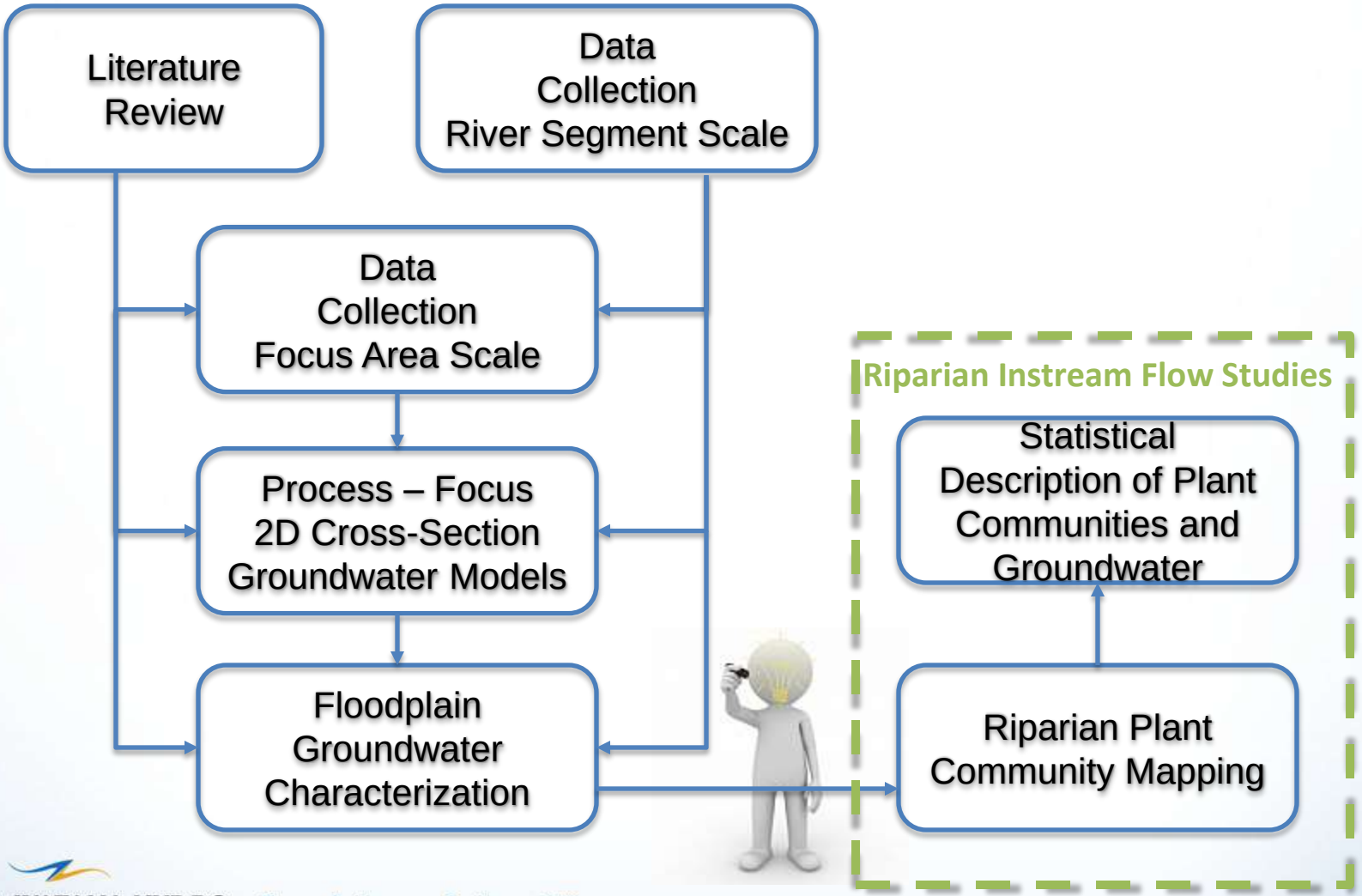
April 29-30, 2014

Prepared by
GW Scientific

Groundwater Study Analysis Approach



Groundwater Study Analysis Process



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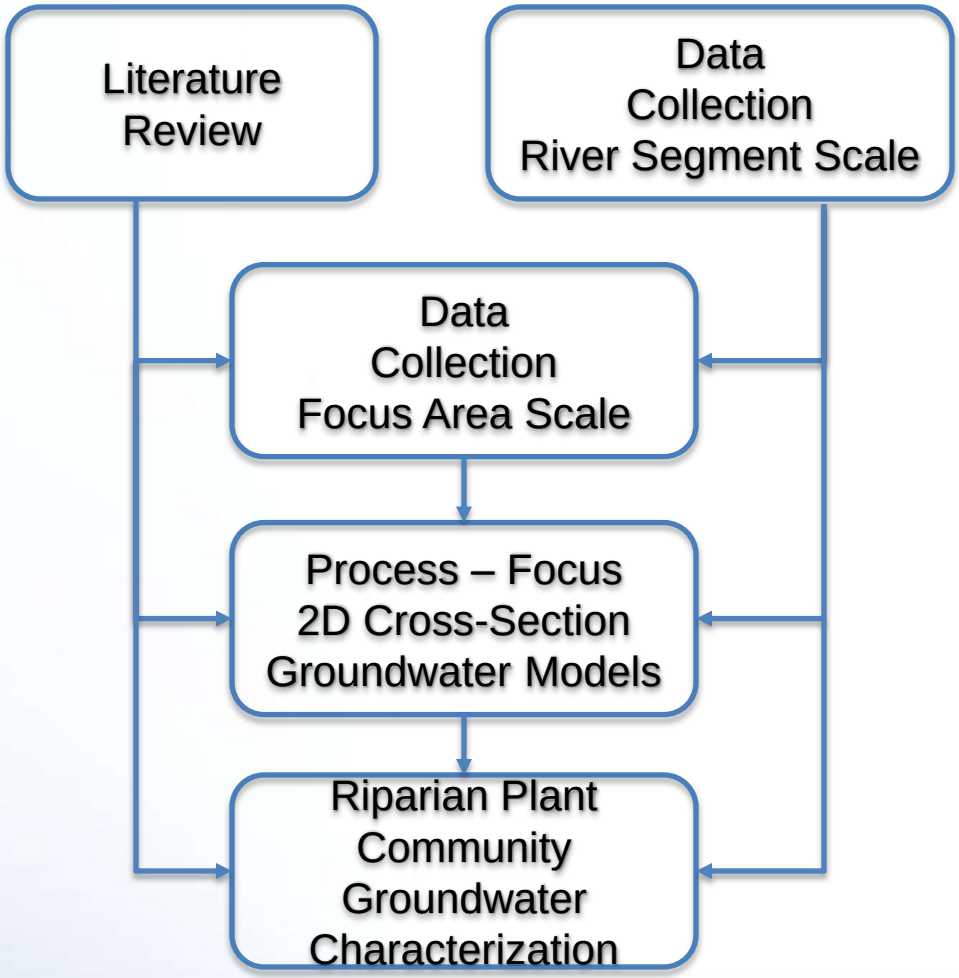
Focus Area Example: FA-104 (Whiskers Slough)



Data Collection on Annual Basis

- Winter and Summer
- Time-Series Information on Transects
- Additional Manual Measurements
- Spatial Data Sets – Thermal Imaging, Aerial Images (Winter, Summer)

Conceptual Models

- Helps Define the Hydrologic System – Groundwater, Surface Water, Atmospheric

Numerical Models

- Provide Process Understanding and Cause/Effect Analysis, Transient Analysis

Groundwater Study Modeling

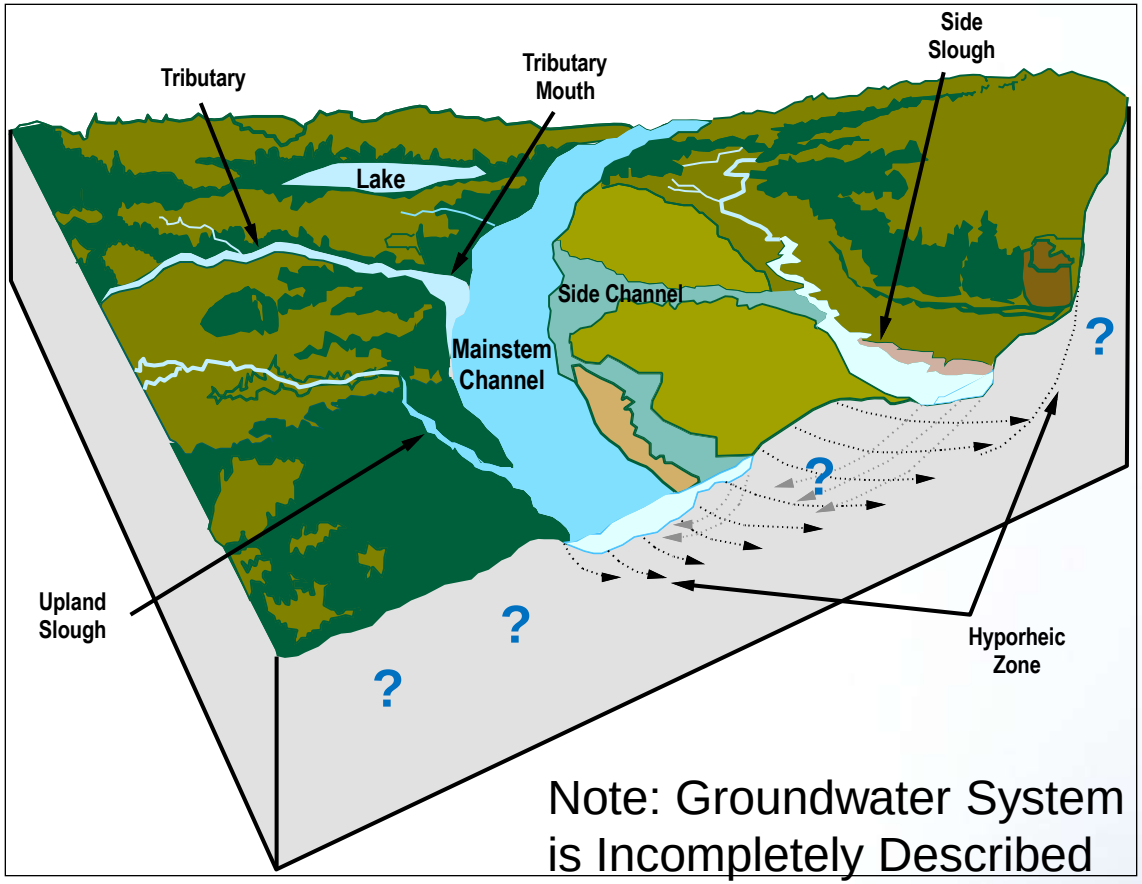
- Why Model?
  - Understand processes we can not easily see
  - Bracket the range of processes interactions
  - Use in combination of other data and studies to guide reasonable estimates of groundwater conditions and potential changes outside the range of natural variability
  - To address specific questions

Groundwater Metrics

- Empirical relationships between groundwater and surface-water systems in relevant Focus Areas.
- Groundwater depths under Project operations conditions.
- Lateral boundary of riverine influences on groundwater levels
- Relative water source distribution in the root zone

Aquatic and Riparian Resources

- Inter-Related
- Impacts on Riparian = 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).

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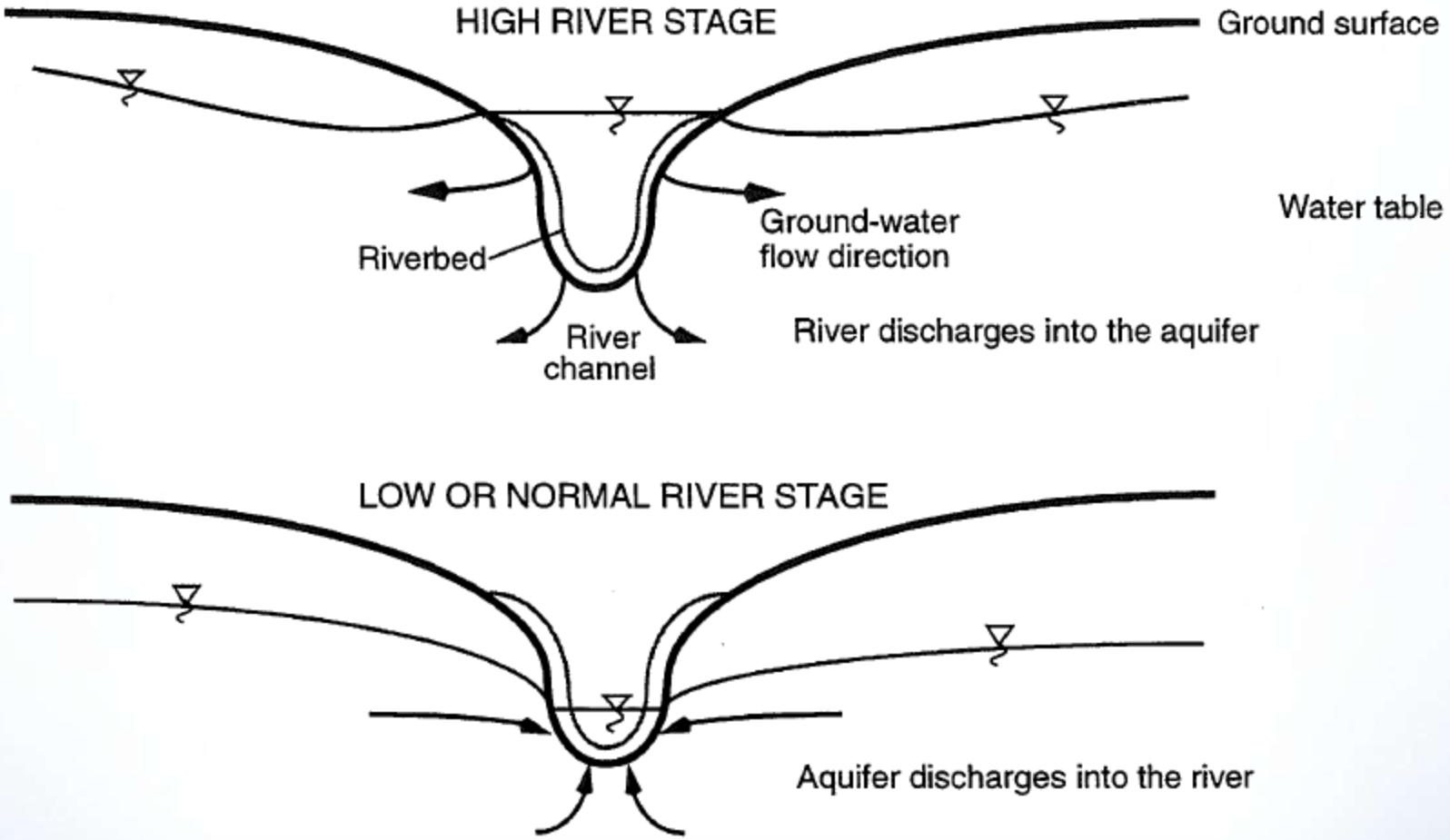
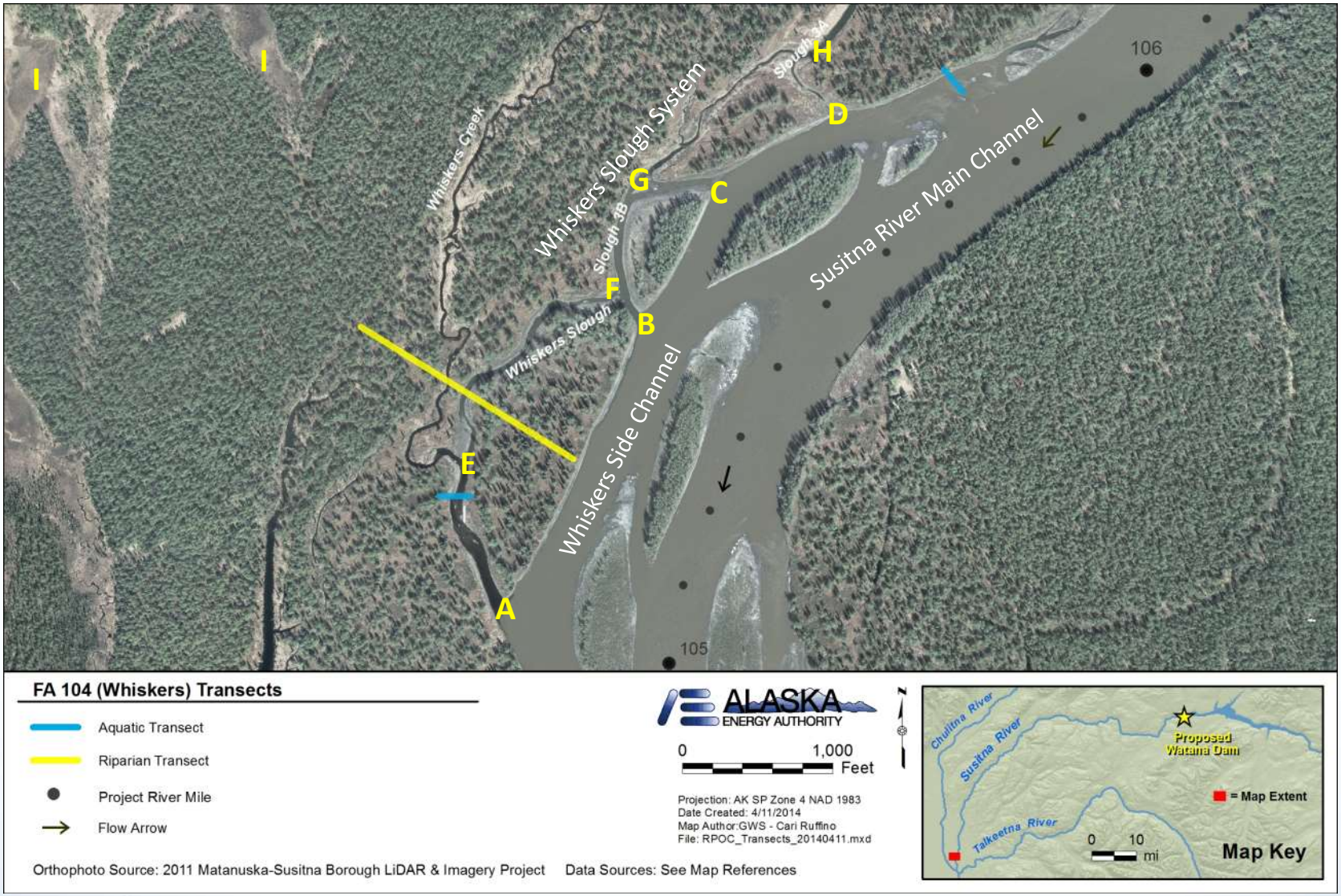
Groundwater/Surface-Water Interaction Processes



FA-104 (Whiskers Slough) Hydrology Features



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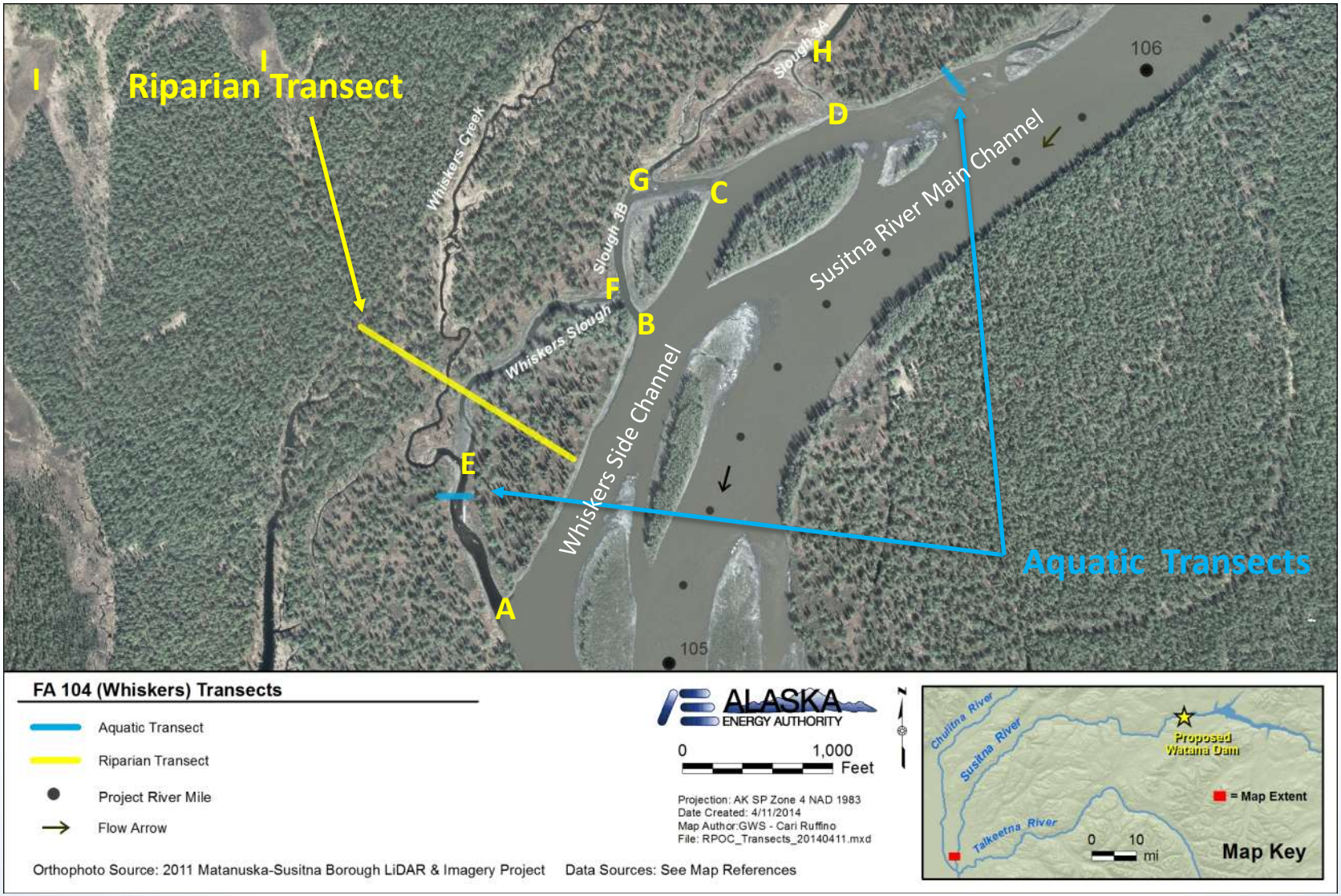
FA-104 (Whiskers Slough) Hydrology Features (A-I)

- A,B,C,D – inlets, outlets between Whiskers Slough System and Whiskers Side Channel
- E – Confluence of Whiskers Creek and Whiskers Slough
- F – Confluence of Whiskers Slough and Slough 3B
- G – Confluence of Slough 3A and 3B
- H – Whiskers Slough (Slough 3A) Upper Section downstream end
- I – Select Recharge Area Examples

FA-104 (Whiskers Slough), Beaver Pond, October 26, 2013

FA-104 (Whiskers Slough) Analysis Transects



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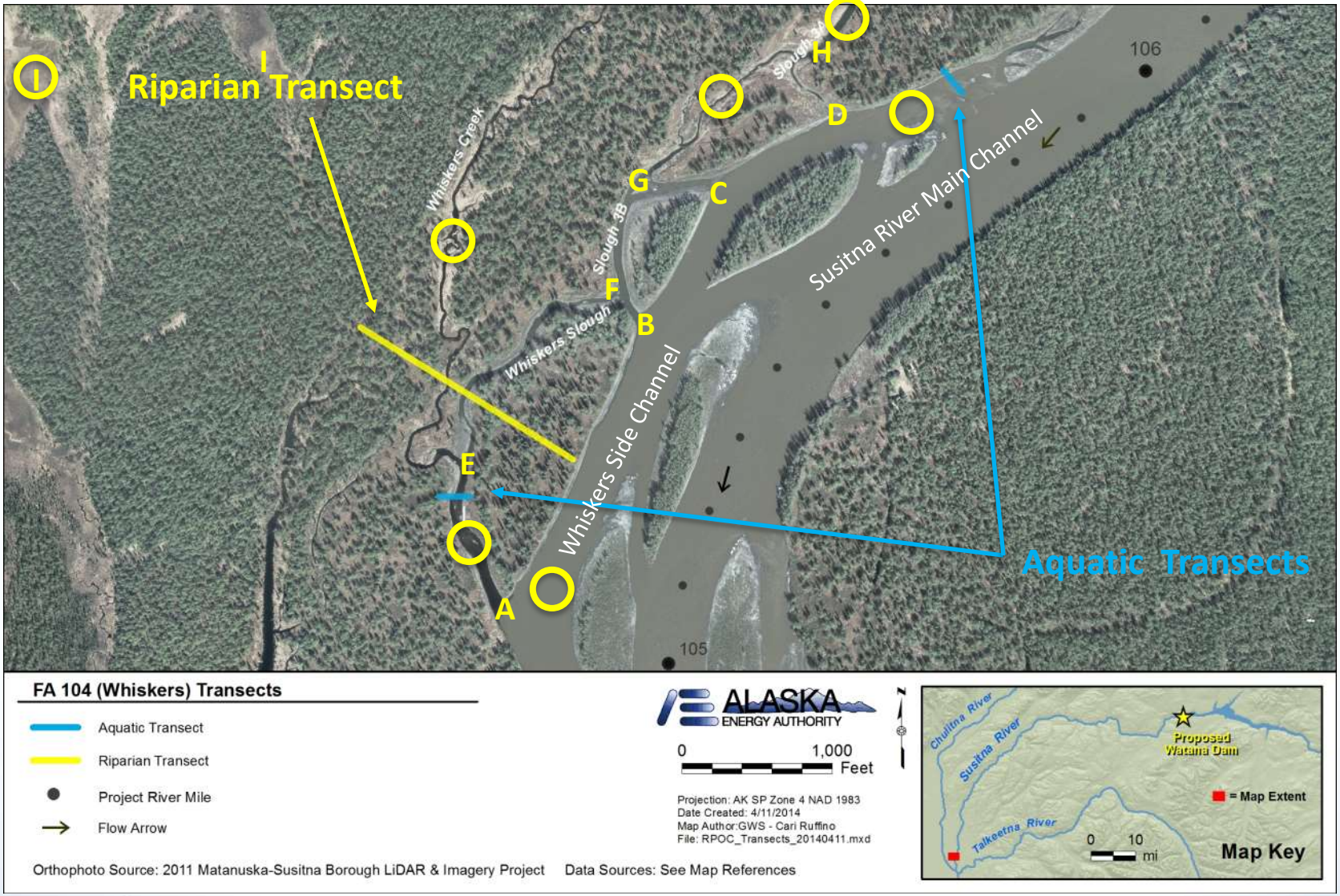
FA-104 (Whiskers Slough) Key Hydrologic Boundaries



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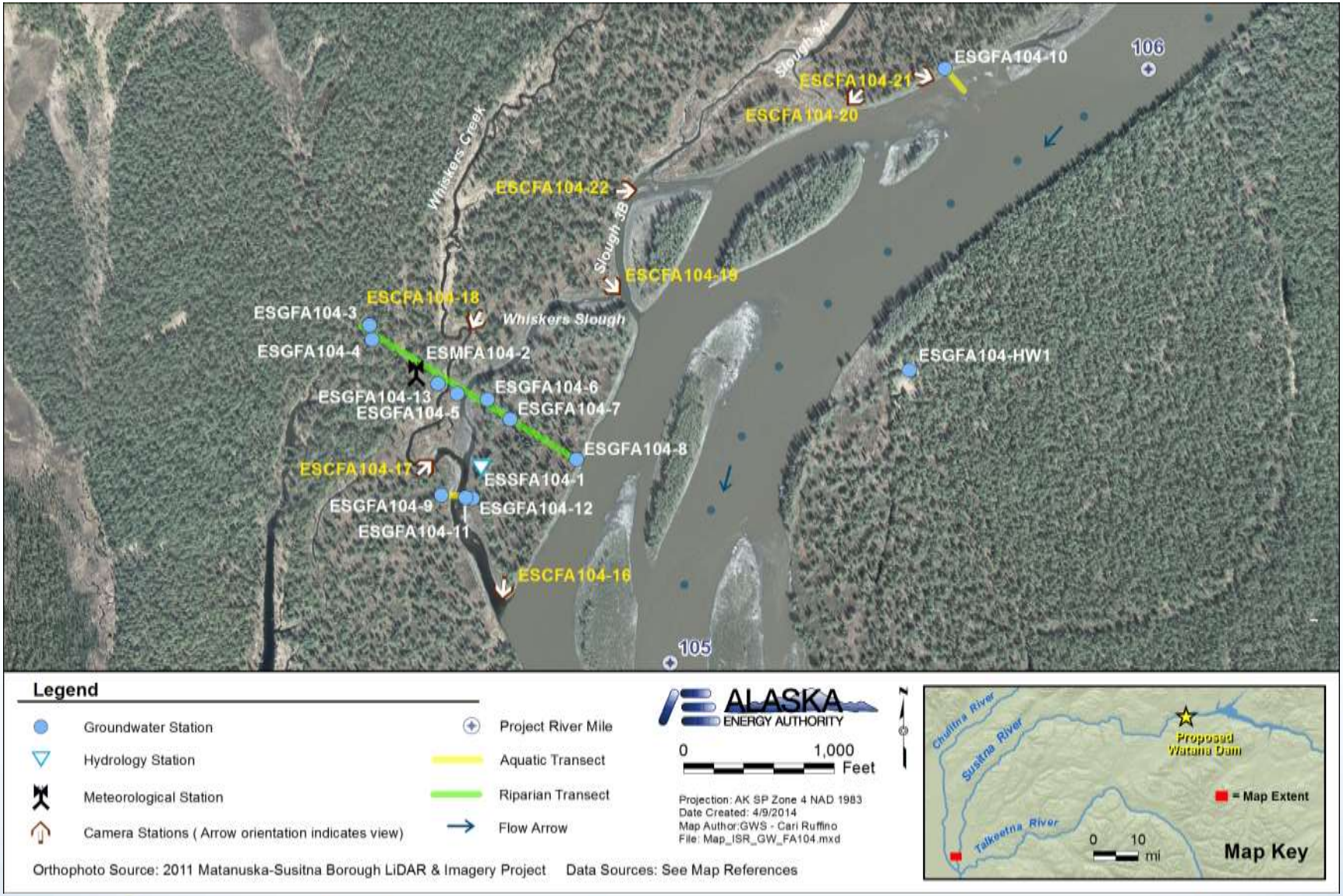
FA-104 (Whiskers Slough) Data Stations



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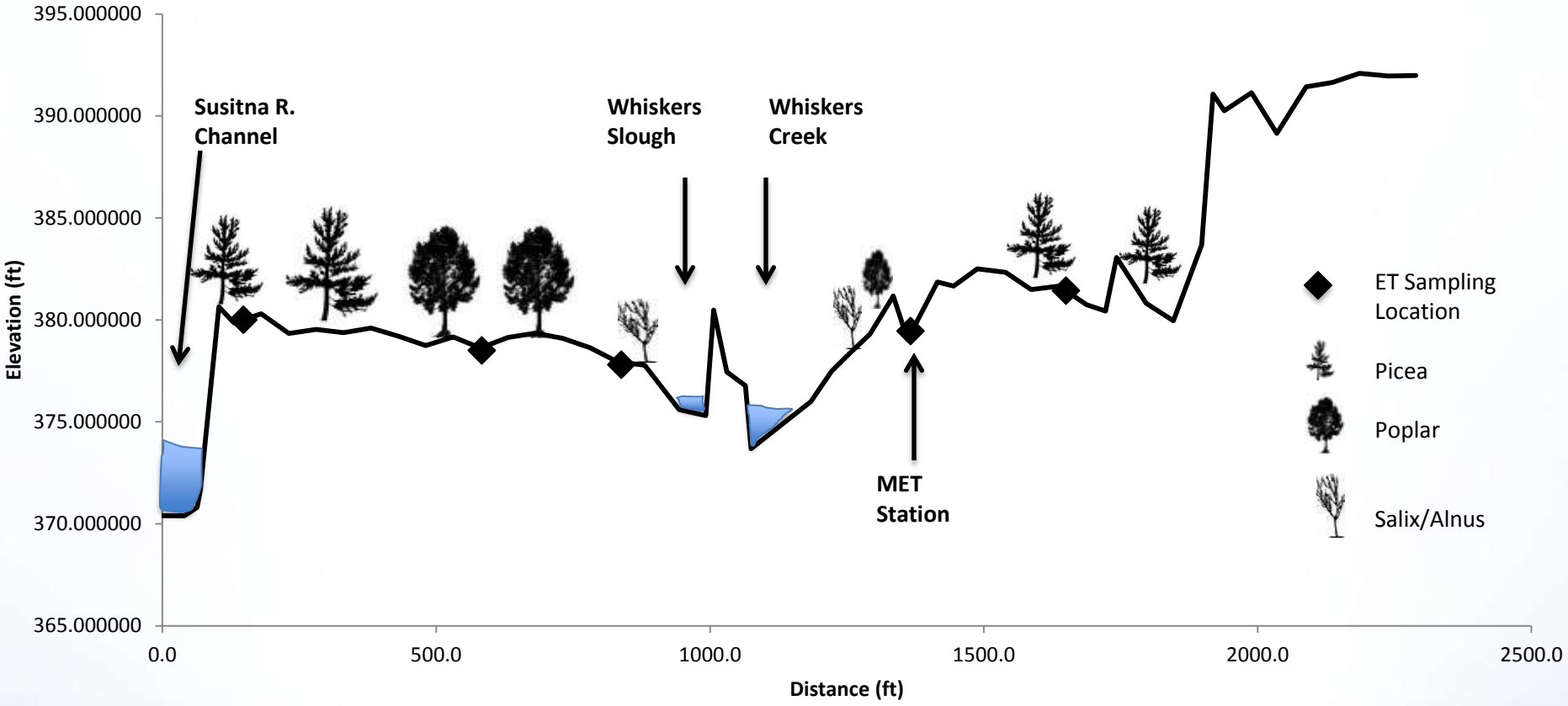
FA-104 (Whiskers Slough) Transect Profile



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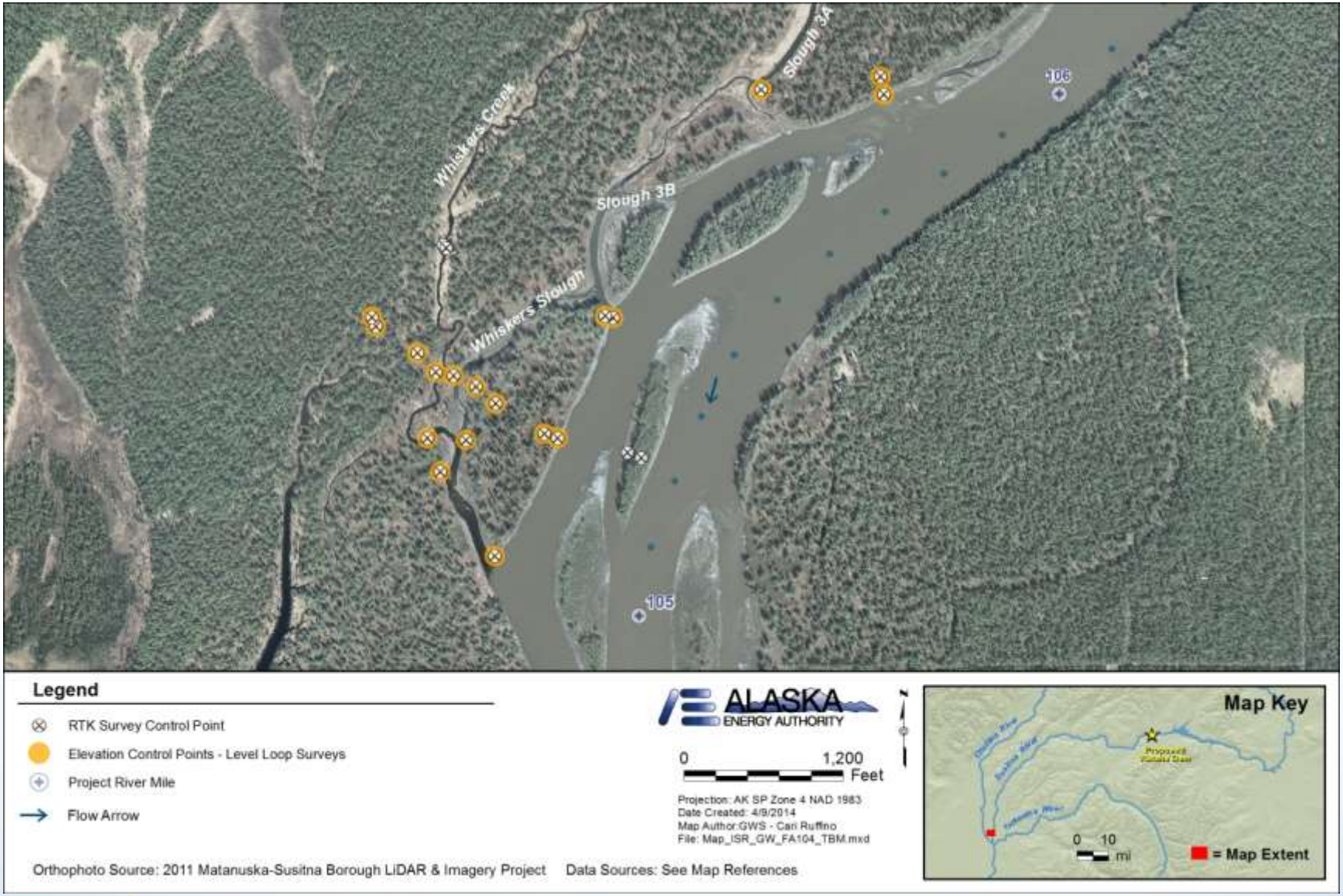
FA-104 (Whiskers Slough) Survey Control



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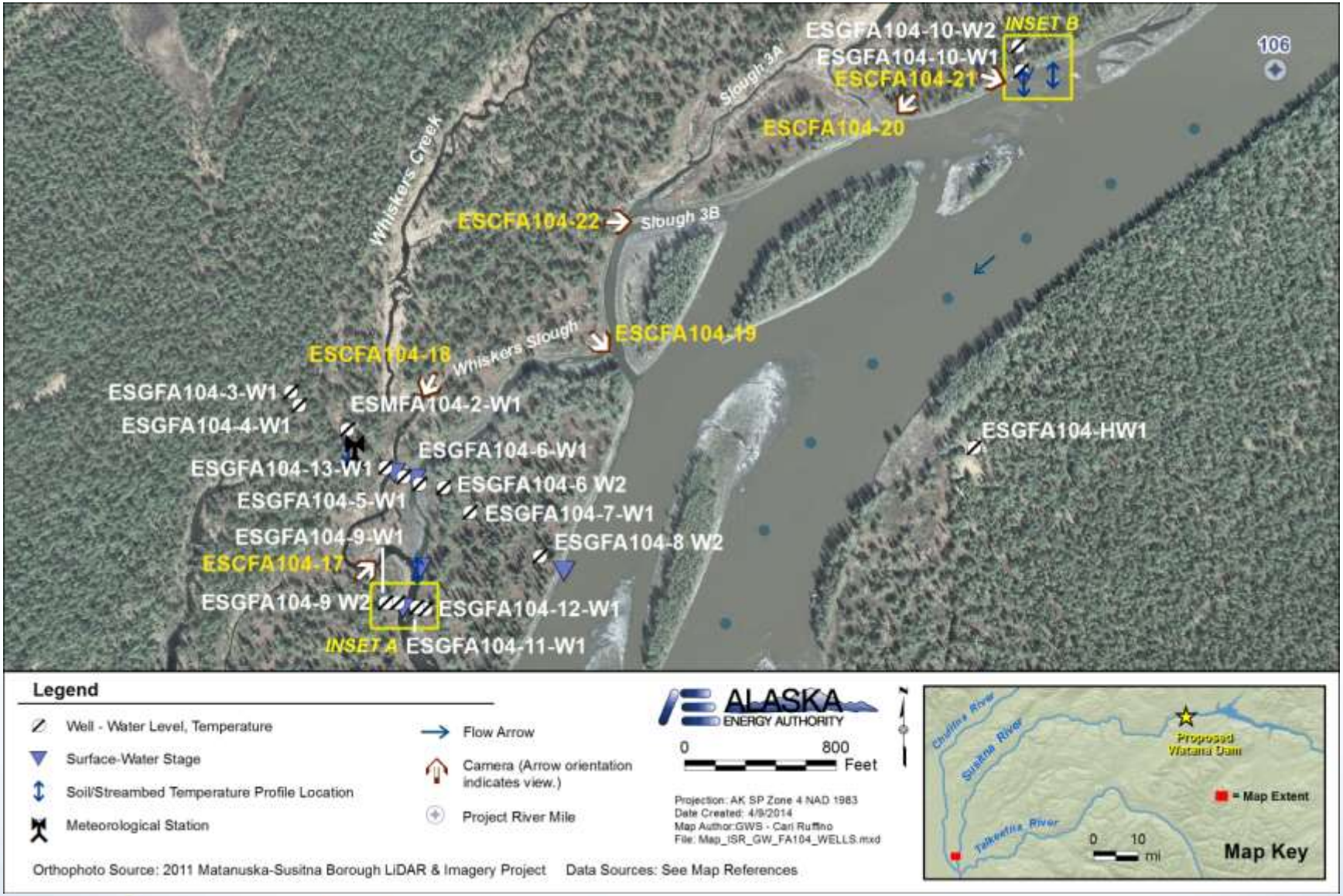
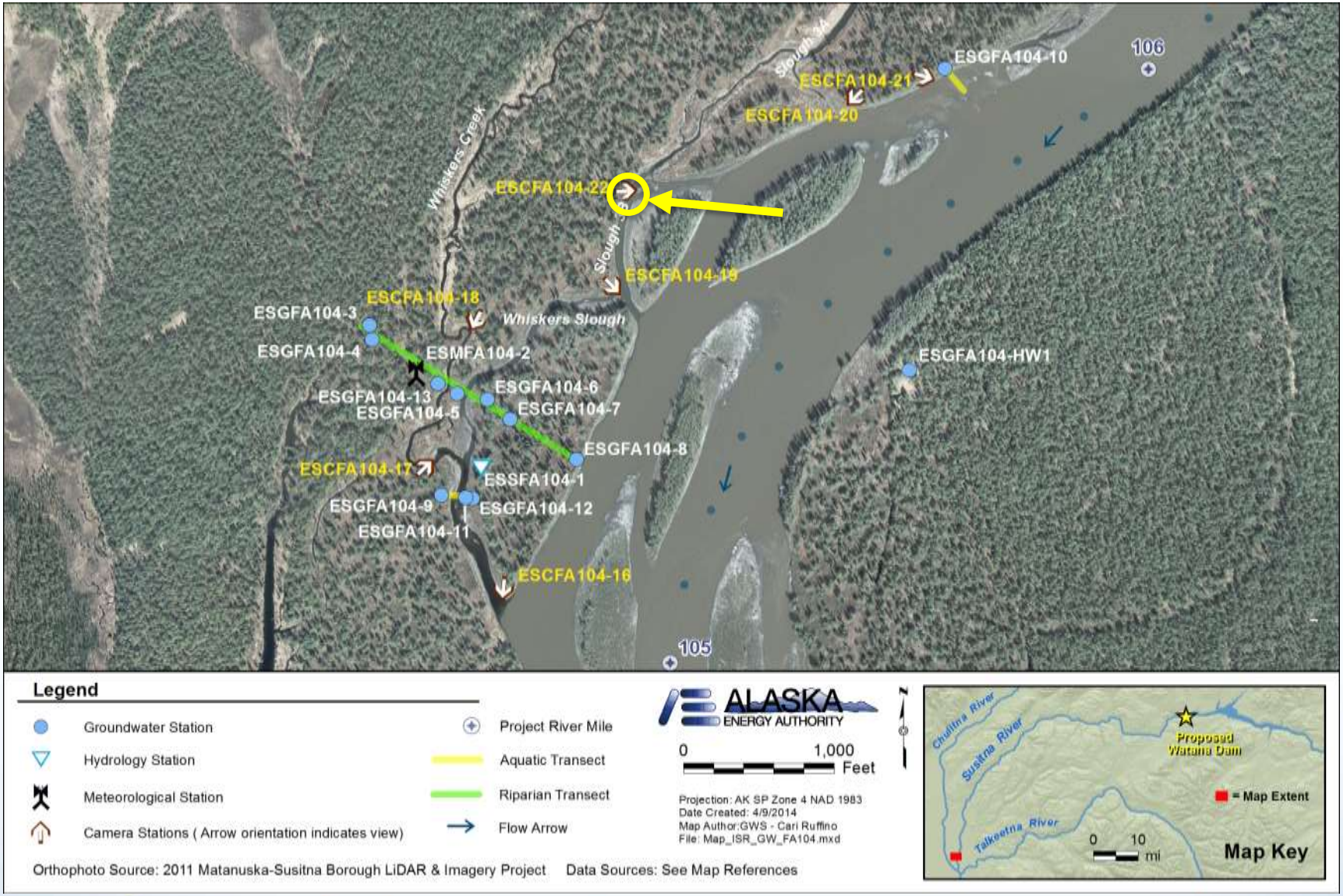
FA-104 (Whiskers Slough) Groundwater Wells



FA-104 (Whiskers Slough) Riparian Transect Stations

ESCFA104-22 Example - Time-Lapse Cameras



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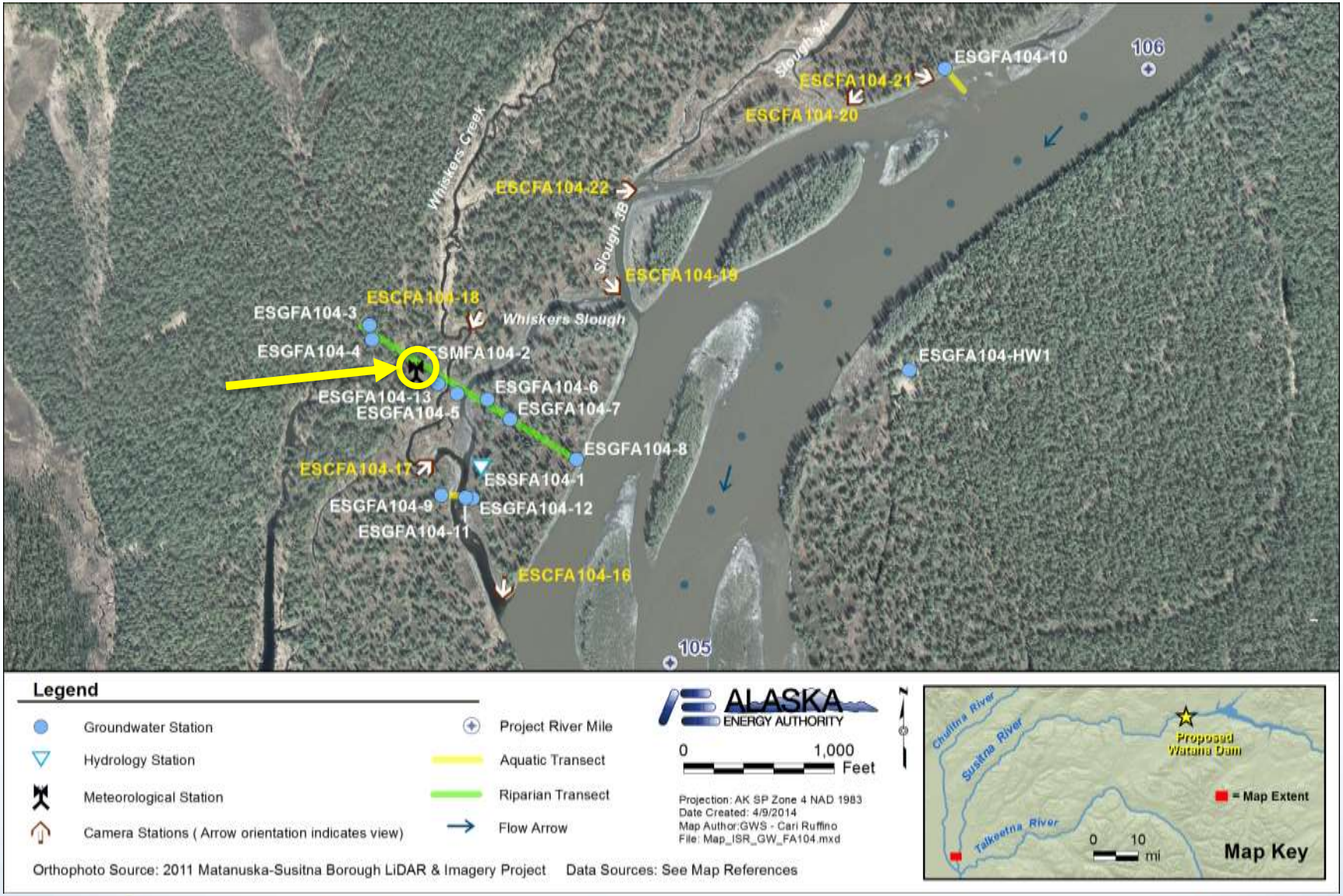
ESCFA104-22 Example - Time-Lapse Cameras

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

ESGFA104-2 Example – Precipitation, Soil Water Content



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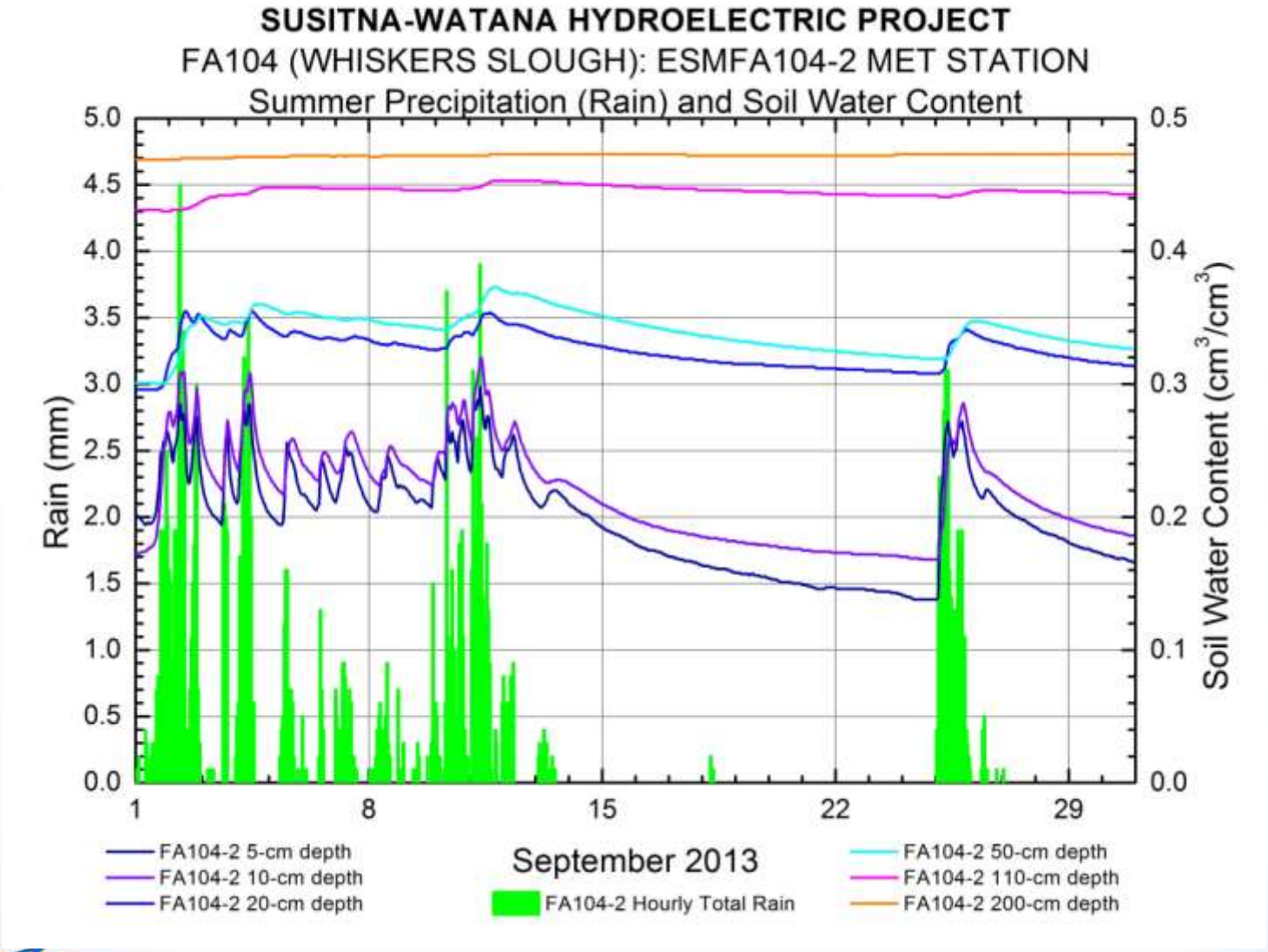
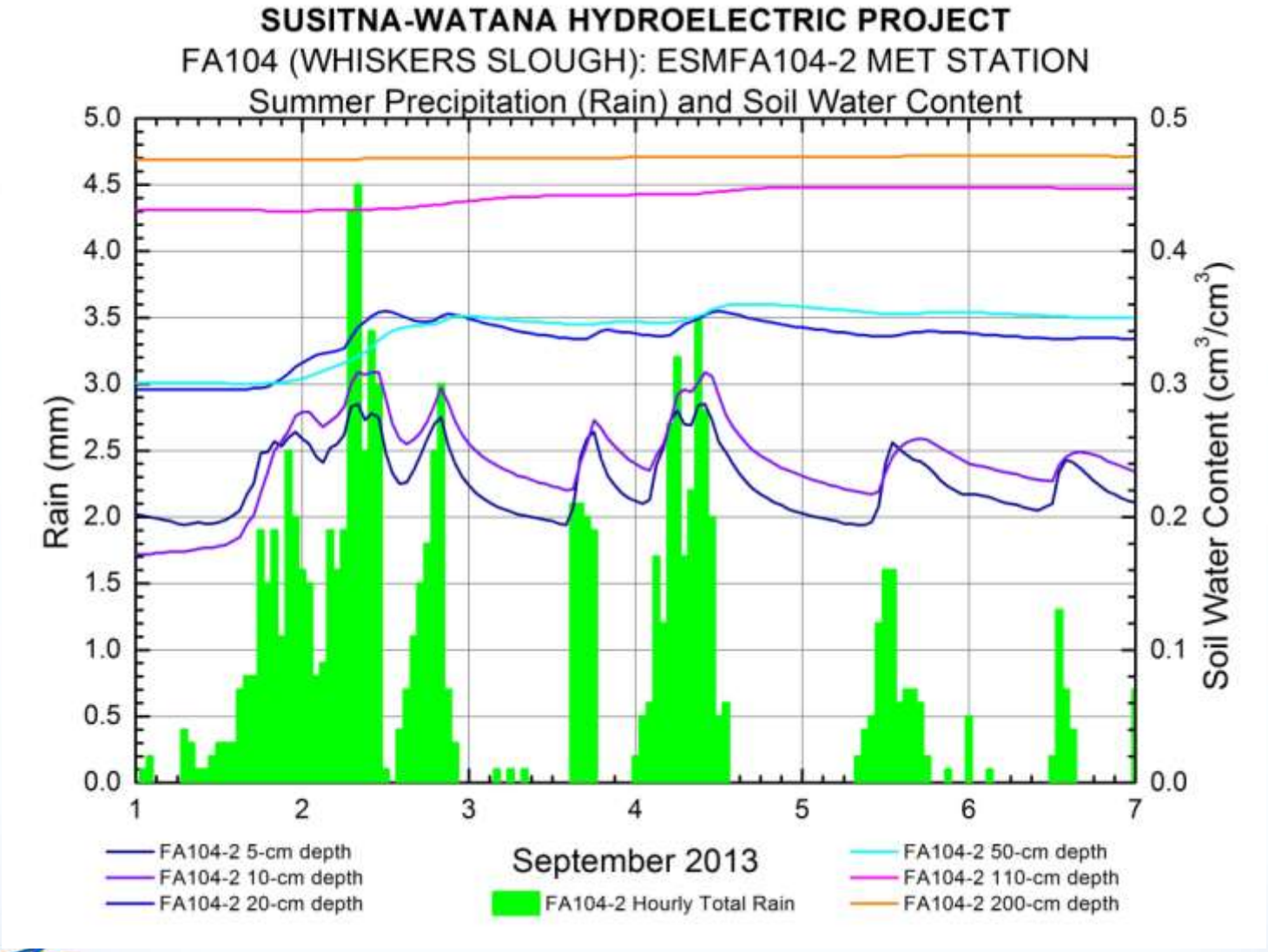
ESGFA104-2 Example - Precipitation, Soil Water Content



ESGFA104-2 Example - Precipitation, Soil Water Content



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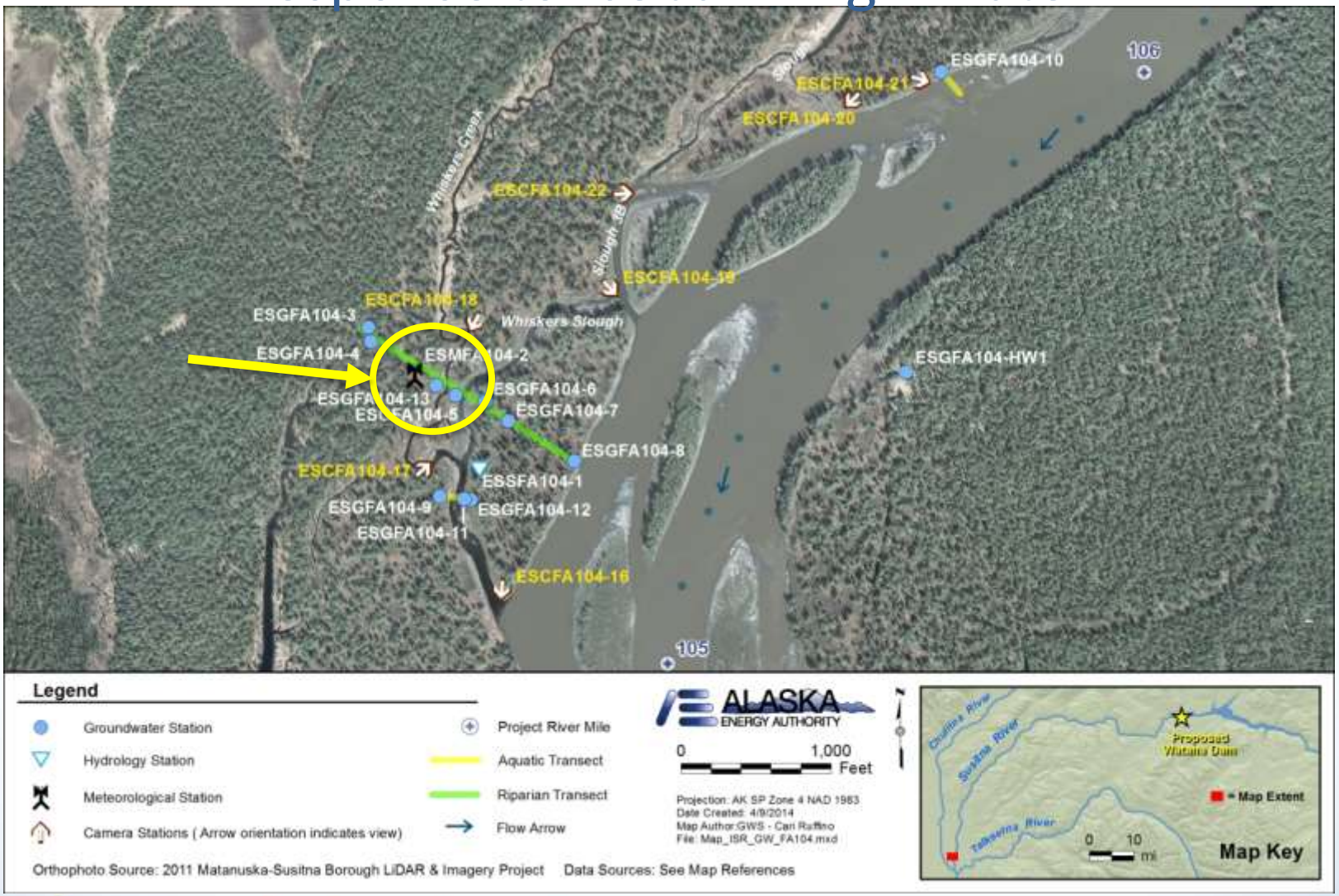
ESGFA104 Example – GW and Soil Moisture Response to Ice Jam High Water



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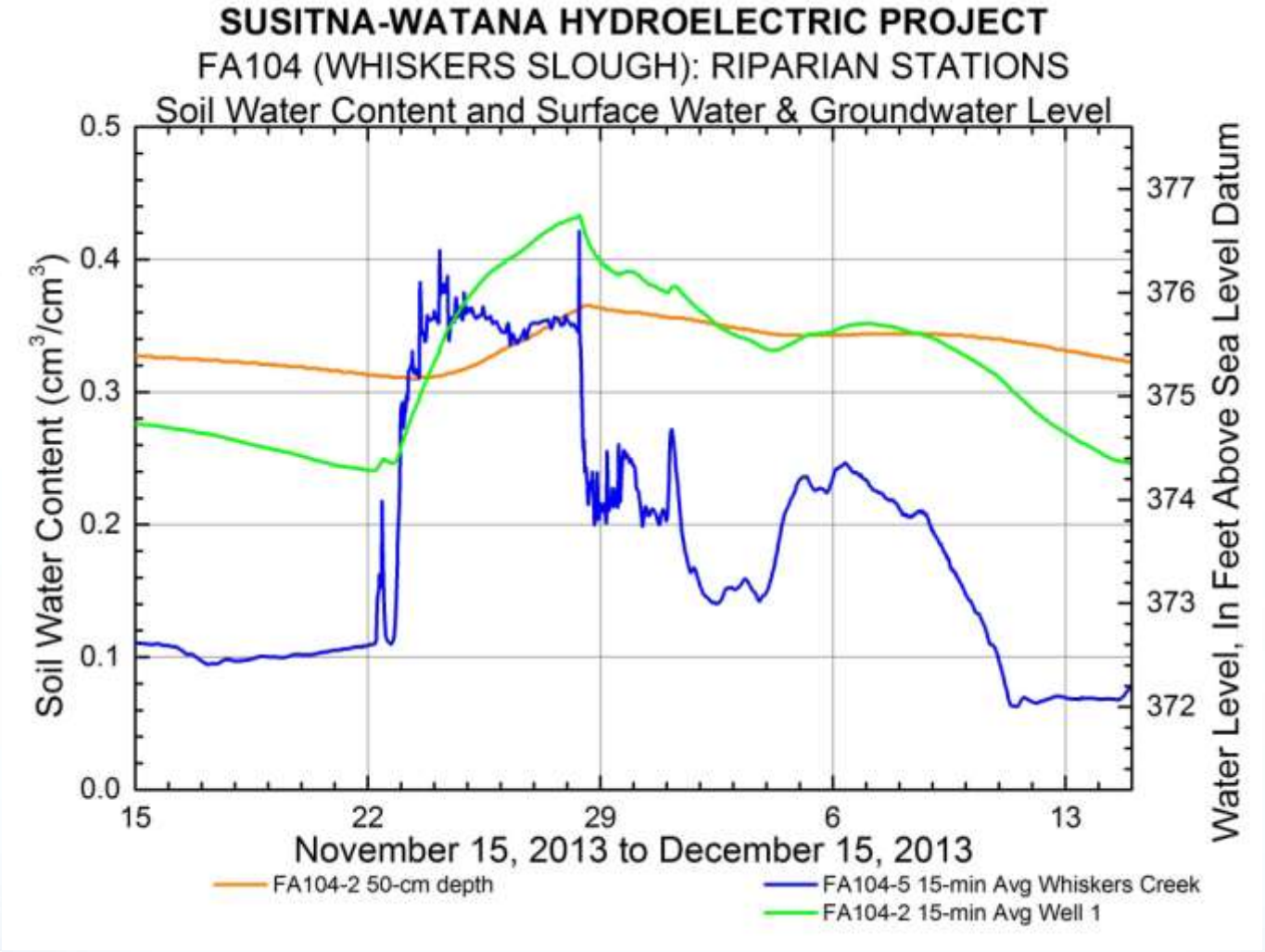
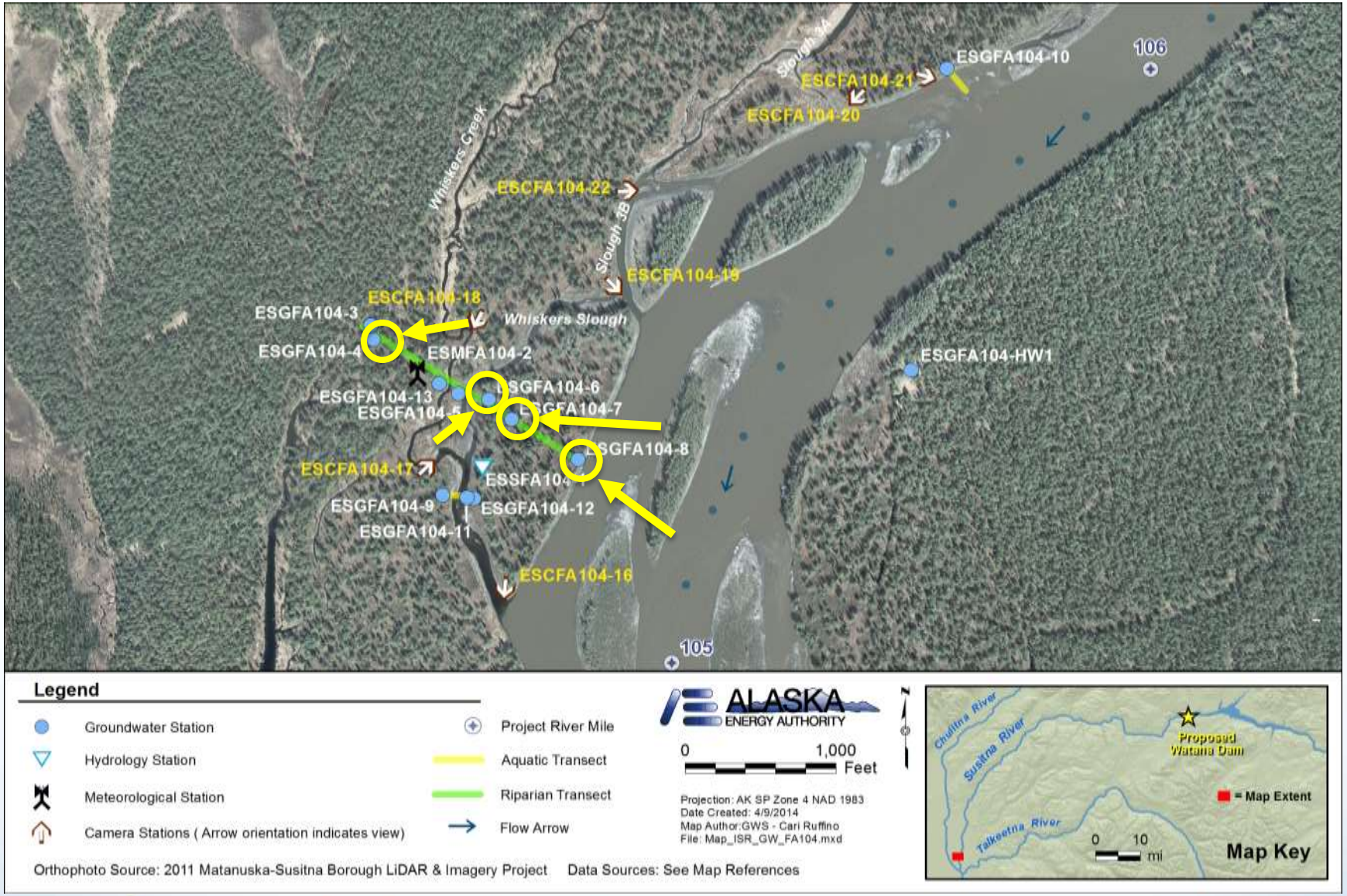
ESGFA104 Example – GW and Soil Moisture Response to Ice Jam High Water



ESGFA104-4, ESGFA104-6,-7,-8 Example – Water Level



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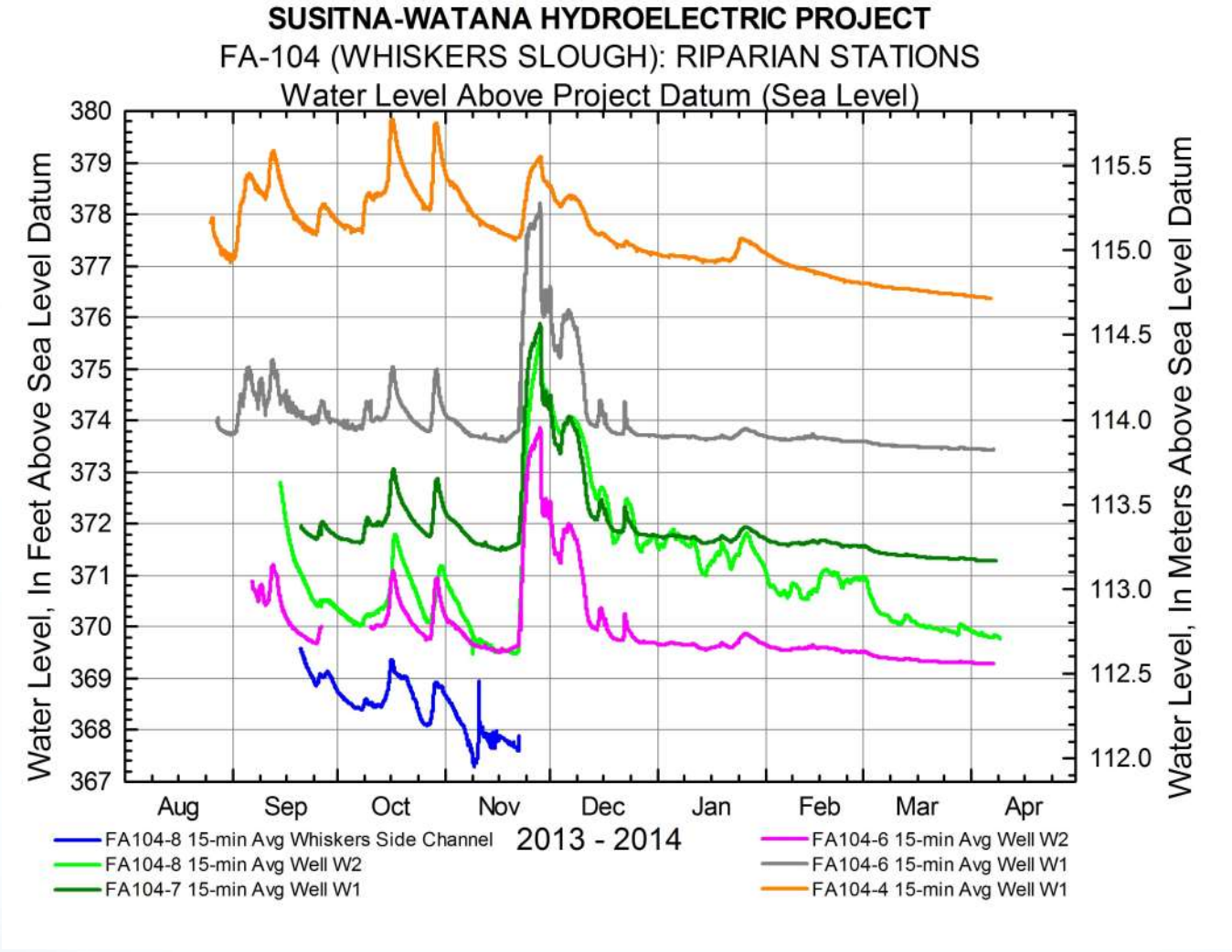
ESGFA104-4, ESGFA104-6,-7,-8 Example – Water Level



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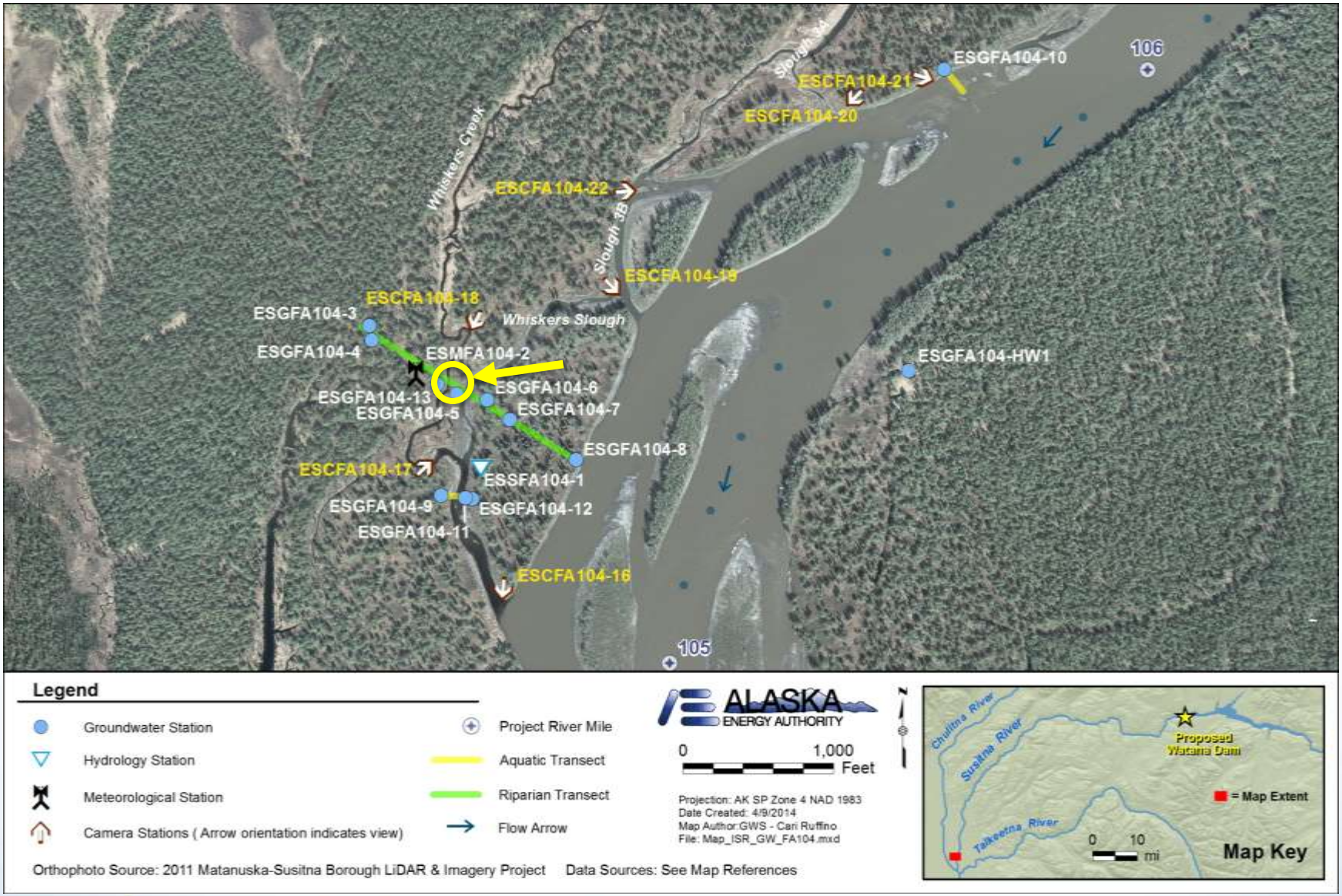
ESGFA104-5 Example – Water Level



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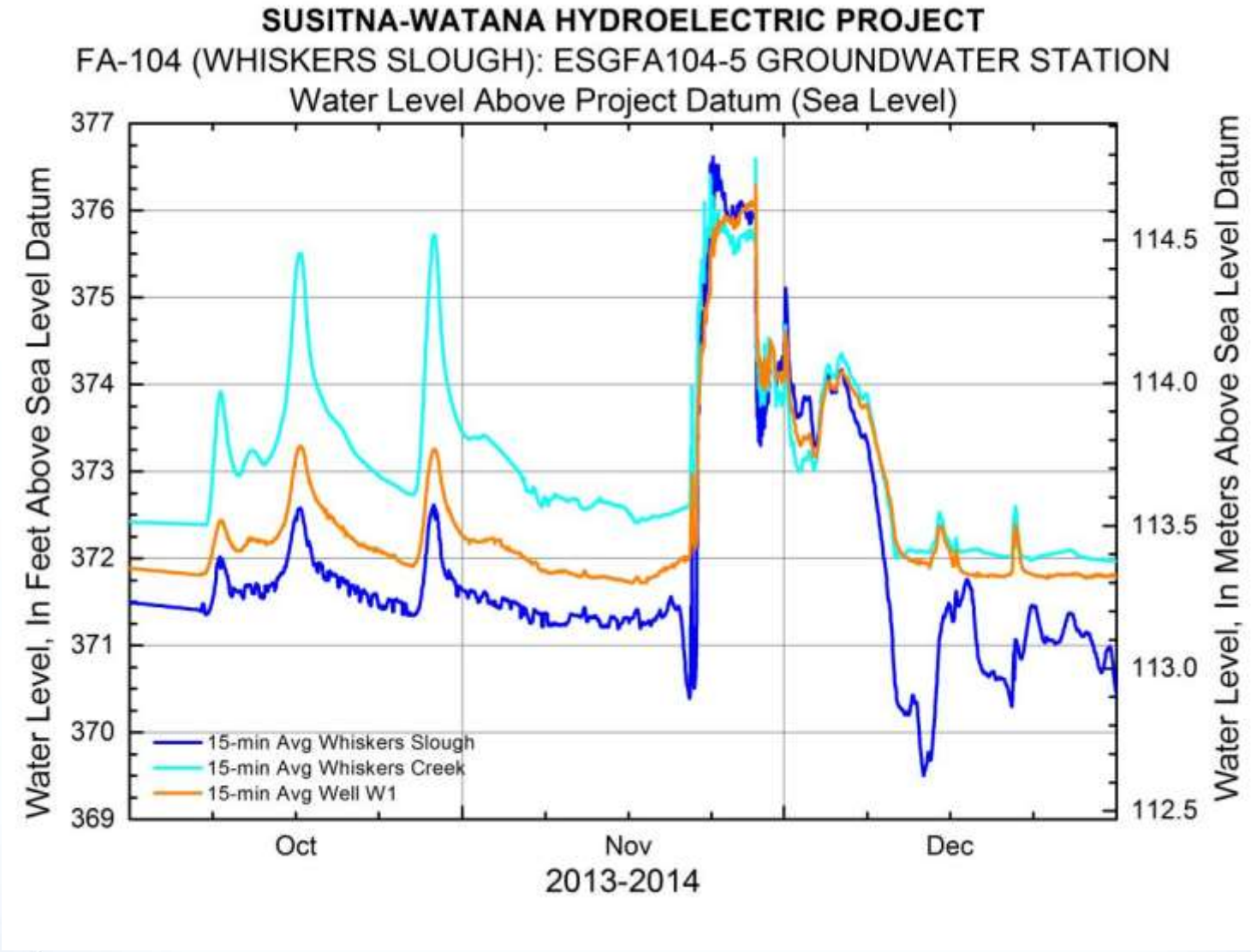
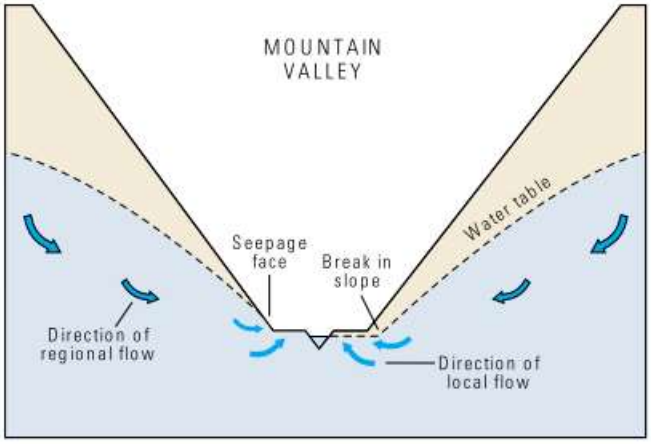
ESGFA104-5 Example – Water Level



Hydrologic Terrain Examples



Mountainous Terrain:

- **Groundwater-supplied "baseflow"**
- **Hyporheic exchange: local-scale importance**

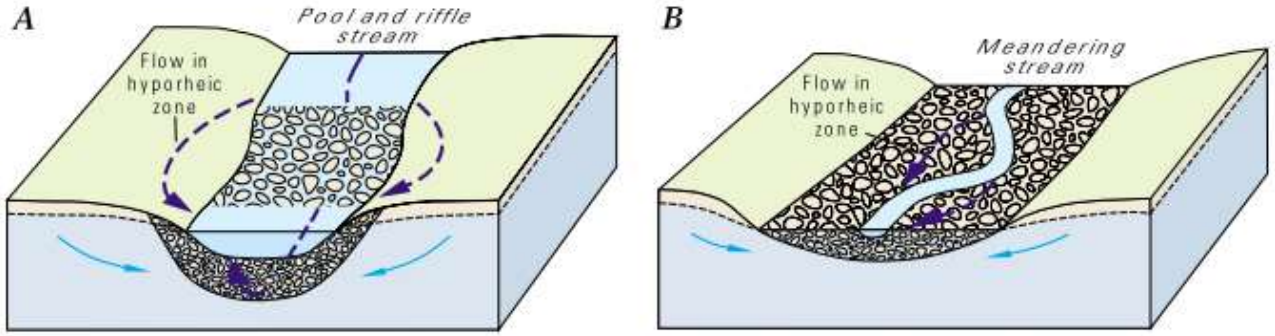
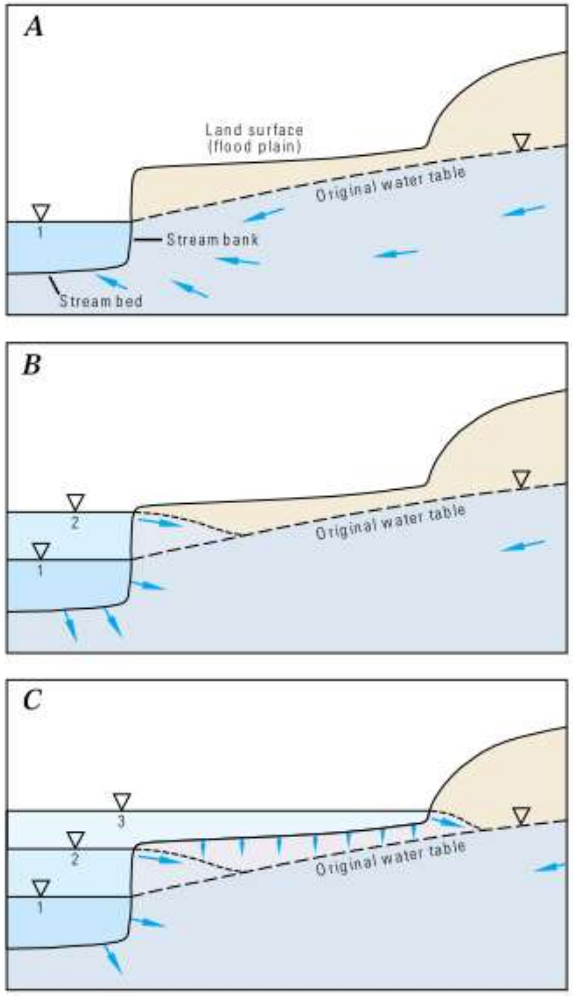


Figure 14. Surface-water exchange with ground water in the hyporheic zone is associated with abrupt changes in streambed slope (A) and with stream meanders (B).

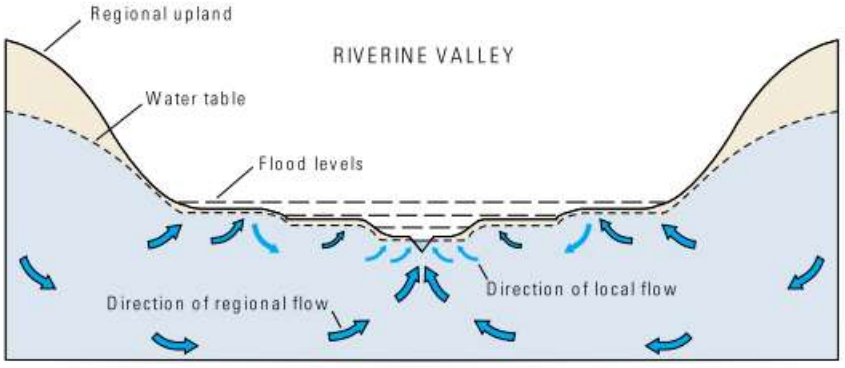
Winter, 1998

Hydrologic Terrain Examples



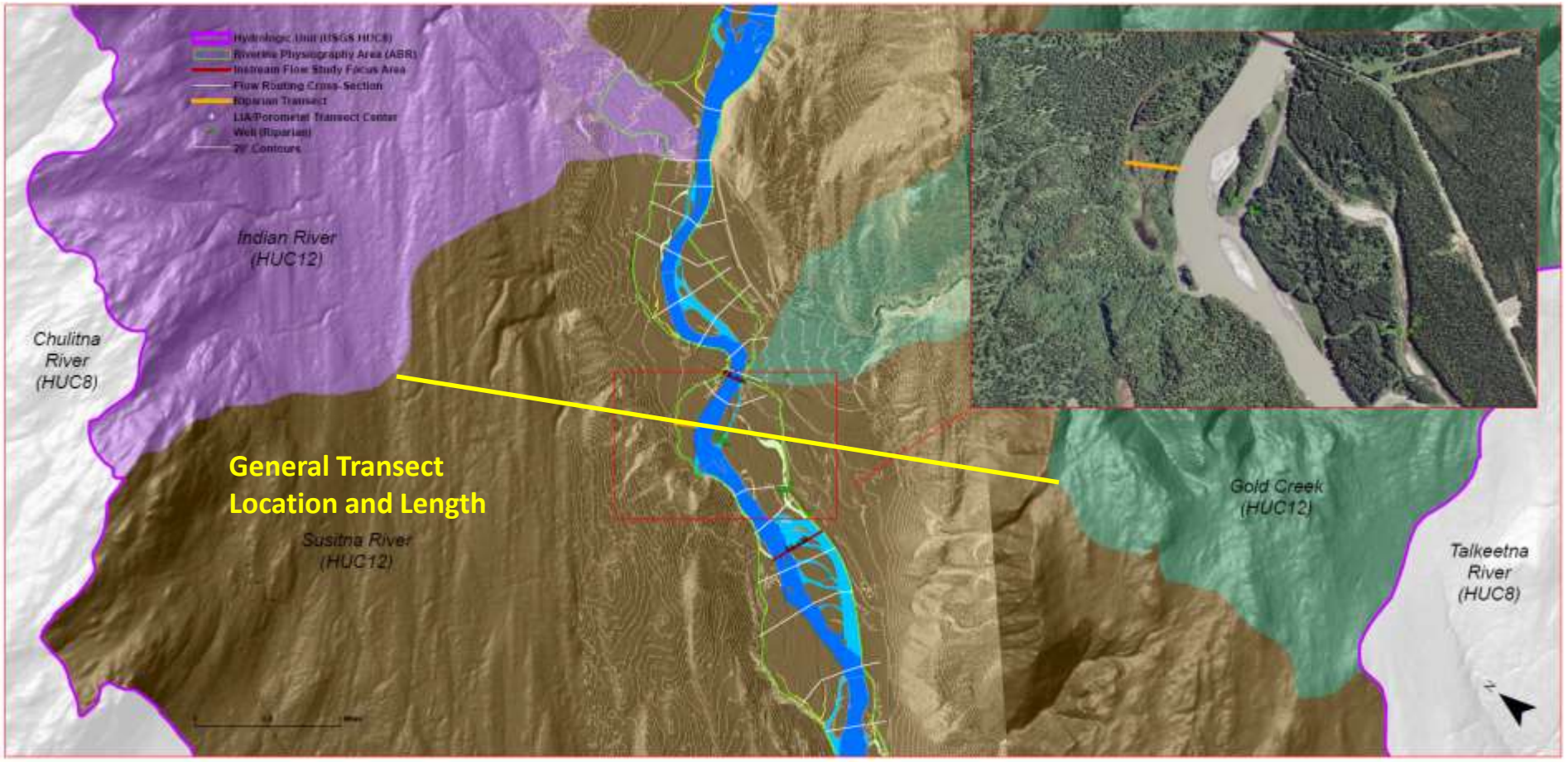
Riverine Terrain:

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



Figures from Winter, 1998

FA-138 (Gold Creek) Terrain Conditions



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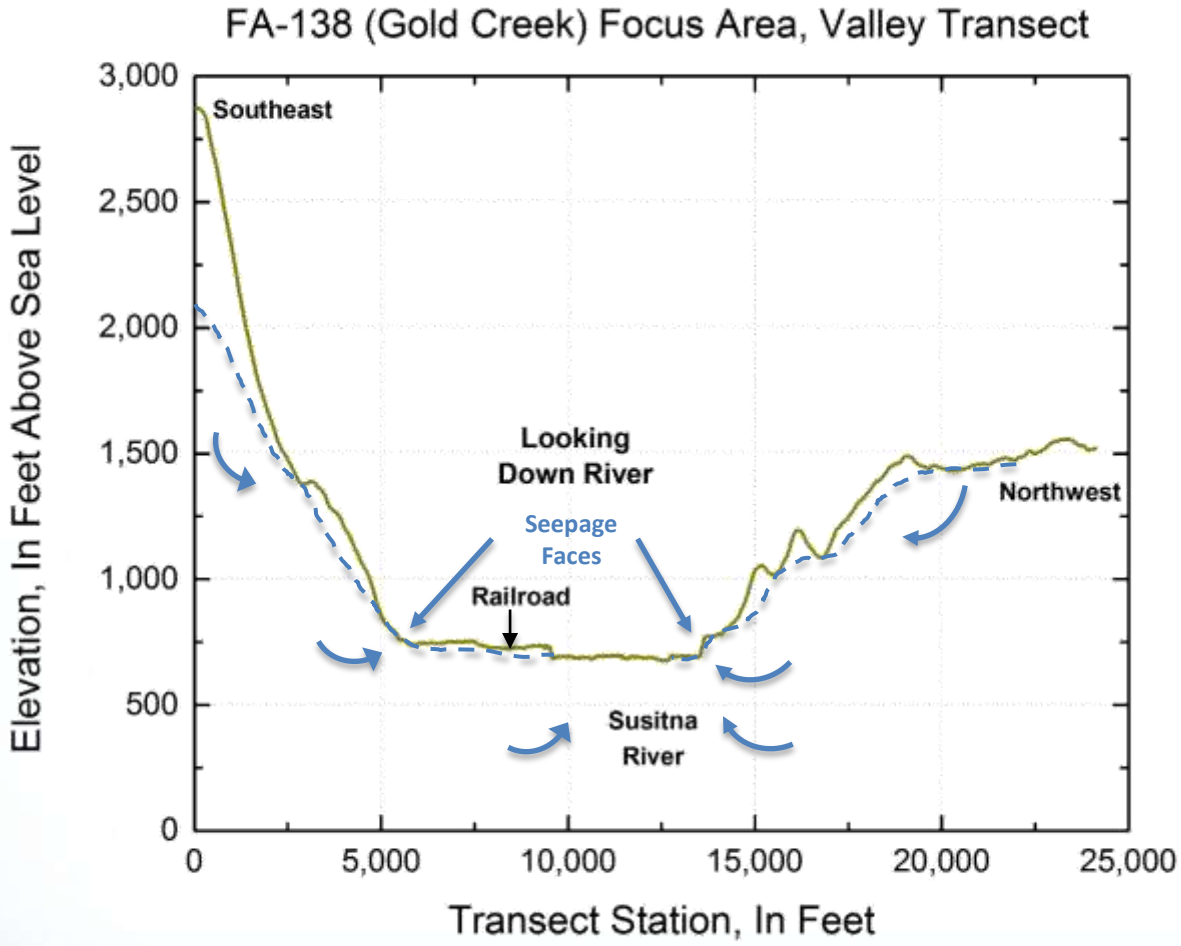
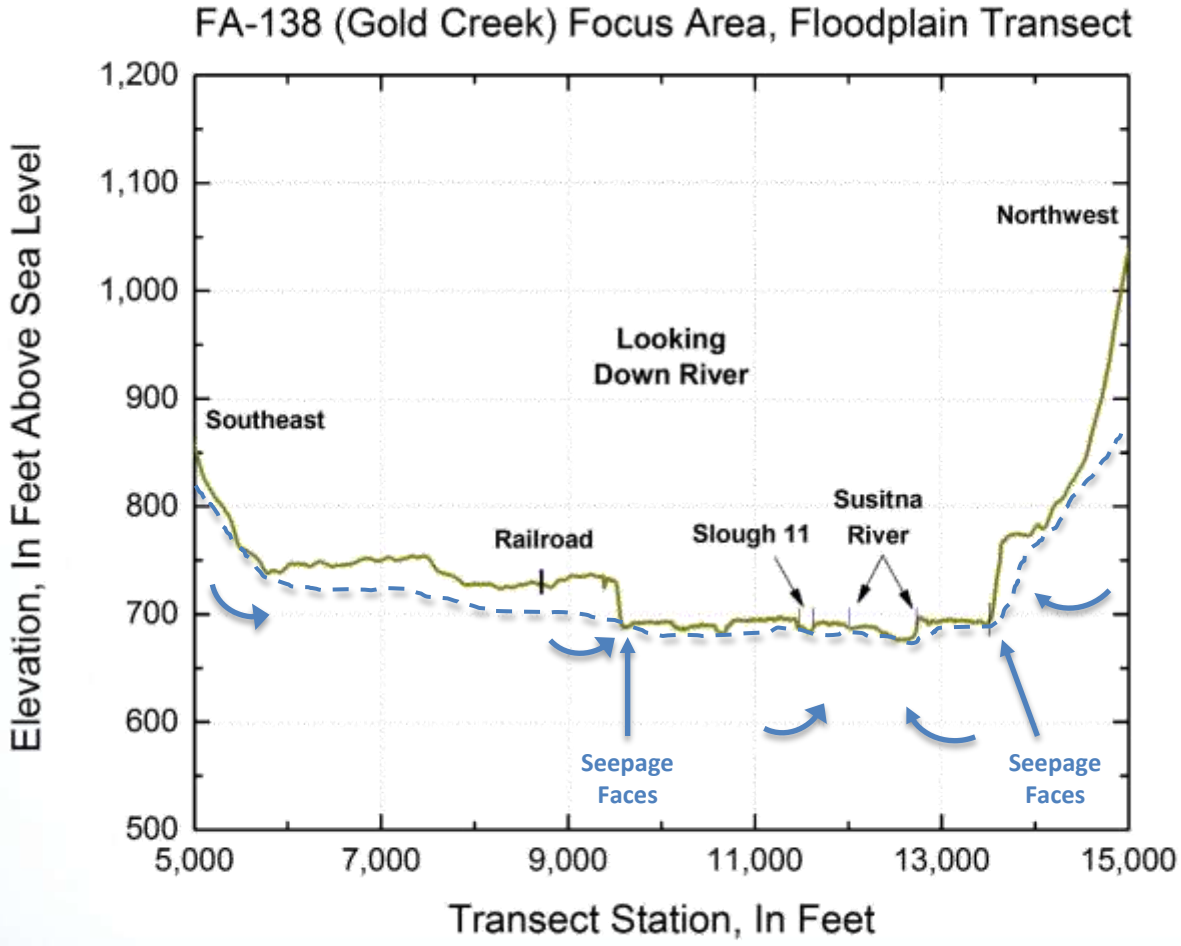
FA-138 (Gold Creek) Terrain Conditions



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

FA-138 (Gold Creek) Terrain Conditions



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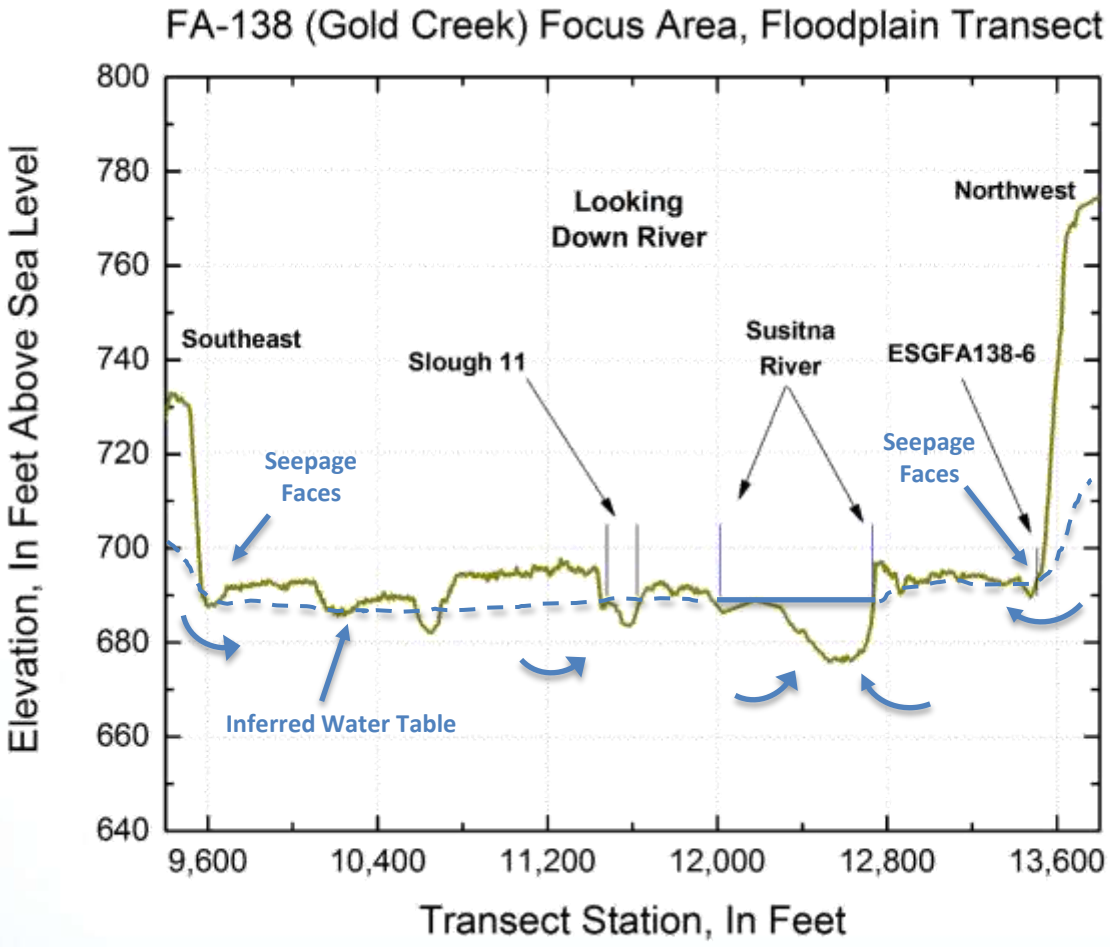
FA-138 (Gold Creek) Terrain Conditions



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FA-138 (Gold Creek) Focus Area Upland Wetland Hydrology Observations

- 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?

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

FA-138 (Gold Creek) Focus Area Upland Wetland Hydrology Observations

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

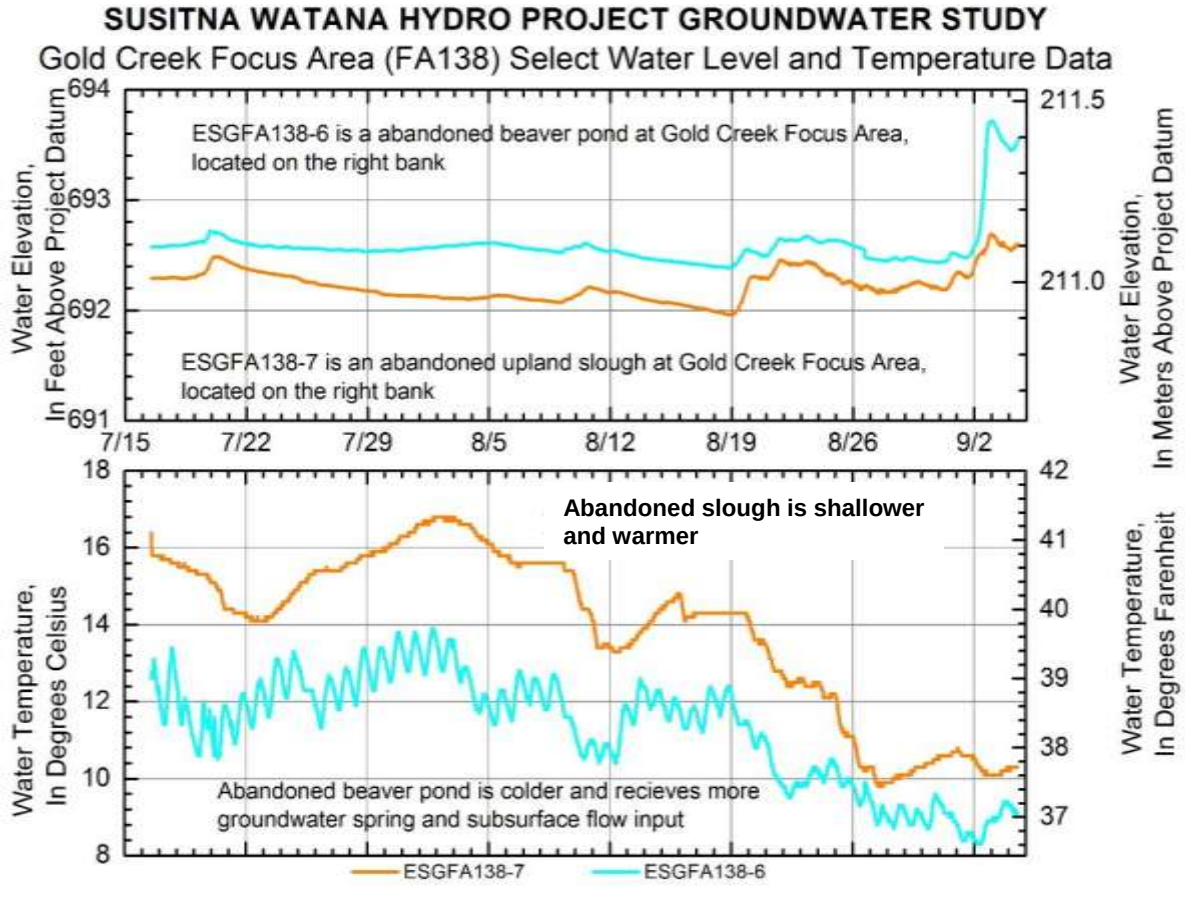
FA-138 (Gold Creek) Focus Area, Right Bank Upland abandoned beaver pond during periods of heavy rains, August 22, 2013

FA-138 (Gold Creek) Focus Area Upland Wetland Hydrology Observations

- Future Shallow Groundwater and Surface Water Level Monitoring
- Seasonal Observations
- Measuring Interactions (Or Lack Of) With River

FA-138 (Gold Creek) Focus Area, Right Bank Abandoned Upland Sloughs and Wetlands, During Periods of Heavy Rain, August 22, 2013

FA-138 (Gold Creek) Focus Area
Upland Wetland Hydrology Observations



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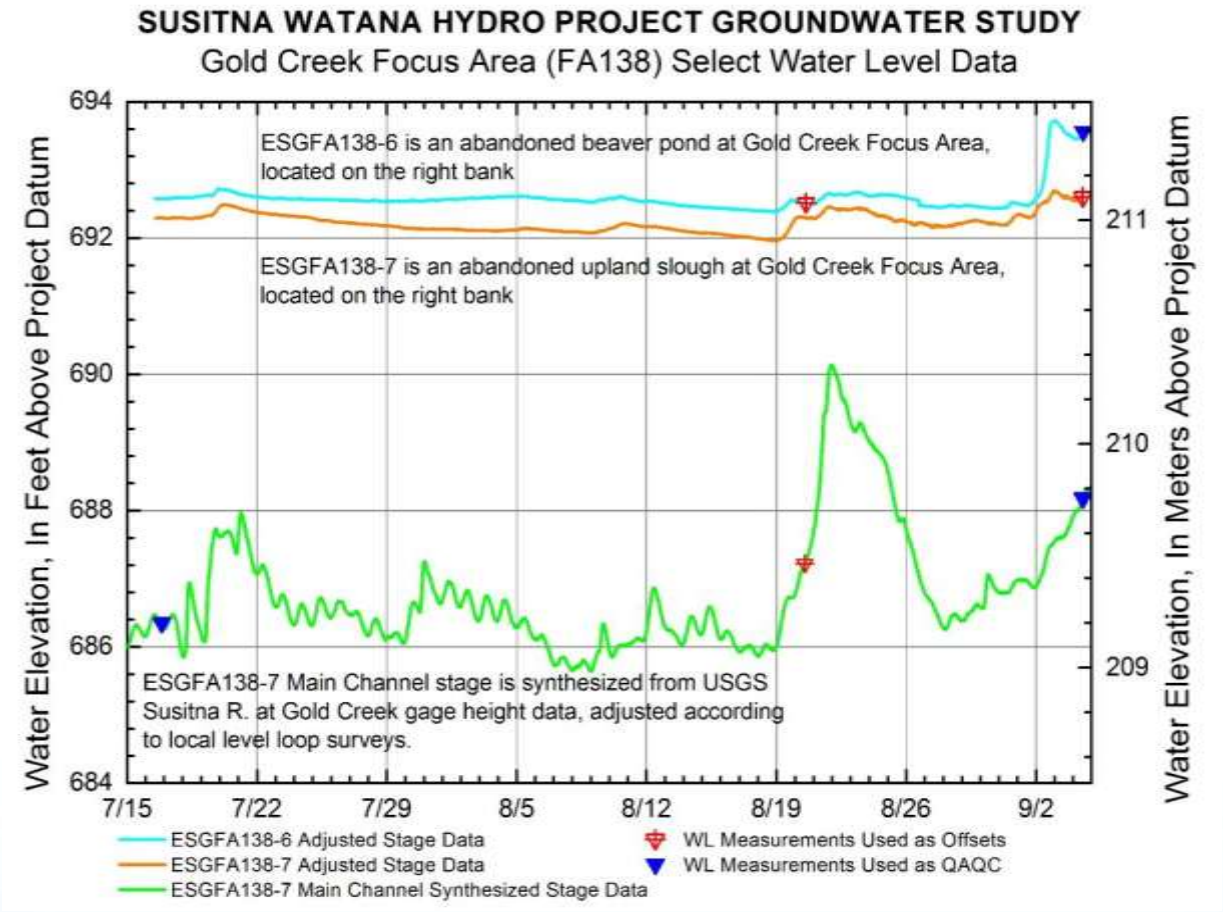
FA-138 (Gold Creek) Focus Area
Upland Wetland Hydrology Observations



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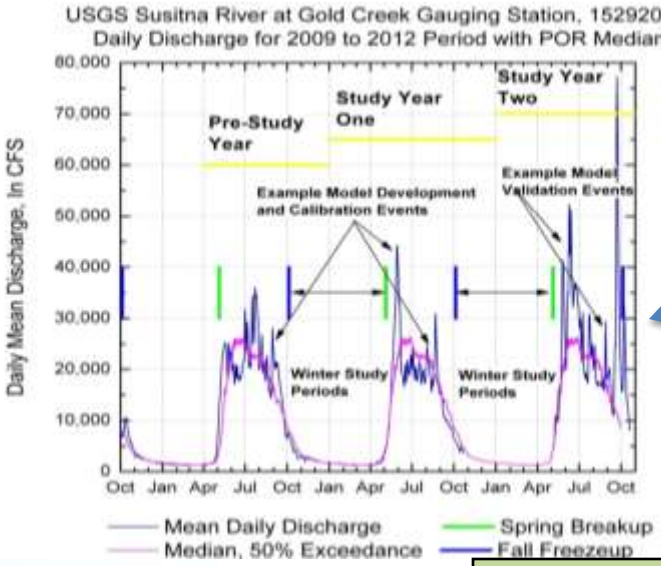
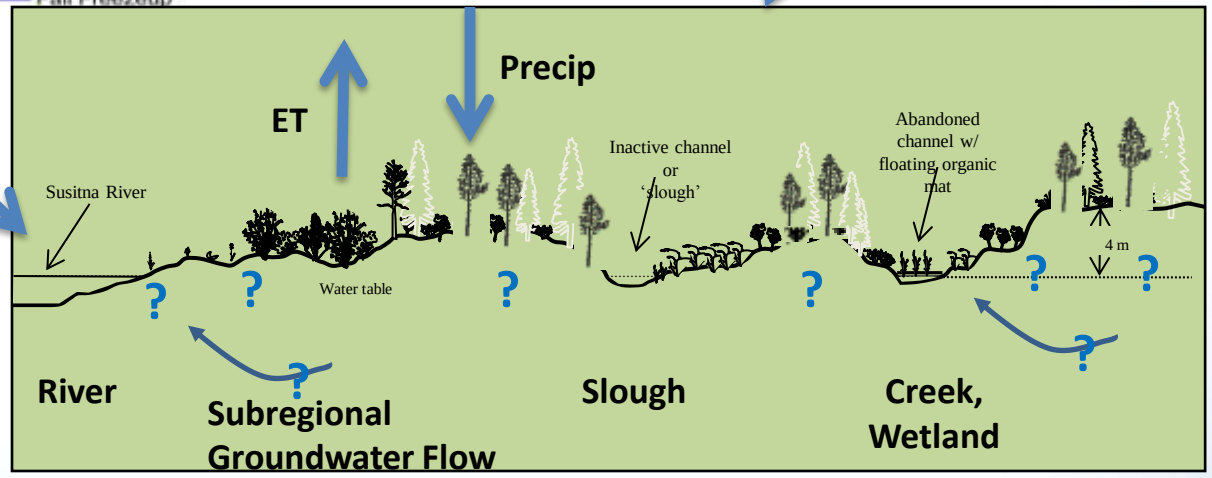
How Does The Natural System Work?



Consider These Surface Water Dynamics with the Below Environment



ET = Evapotranspiration

Looking Downstream, (note: groundwater flow is not 2D)

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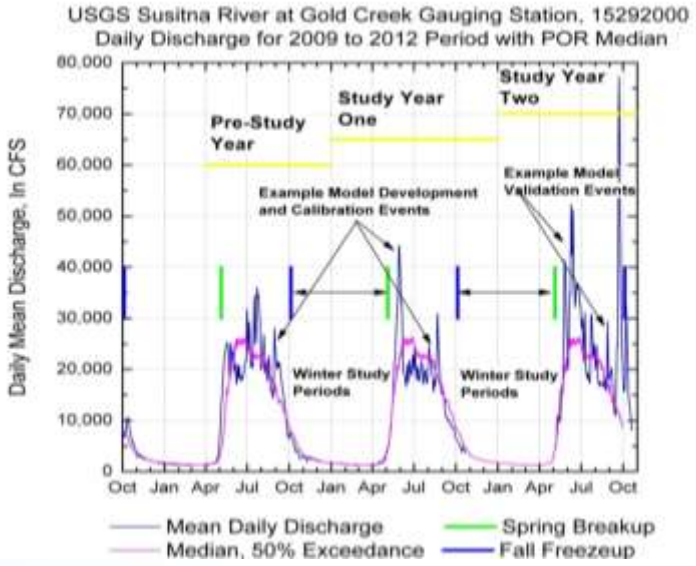
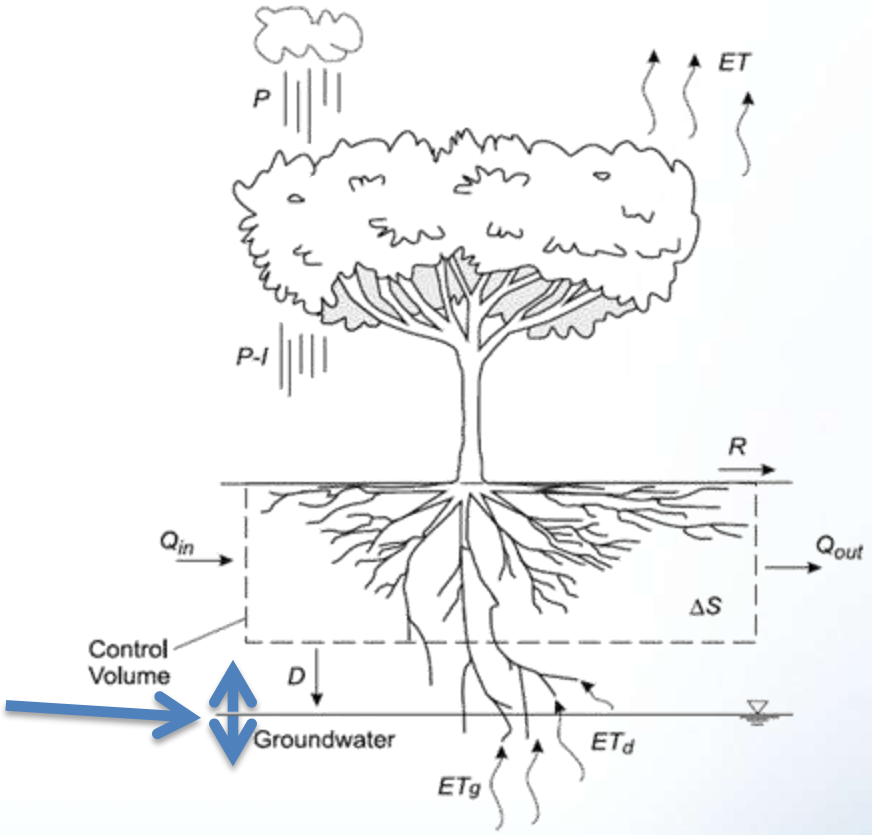
How Does The Natural System Work?



Consider These Surface Water Dynamics and How They Change The Water Table with Every Stage Change



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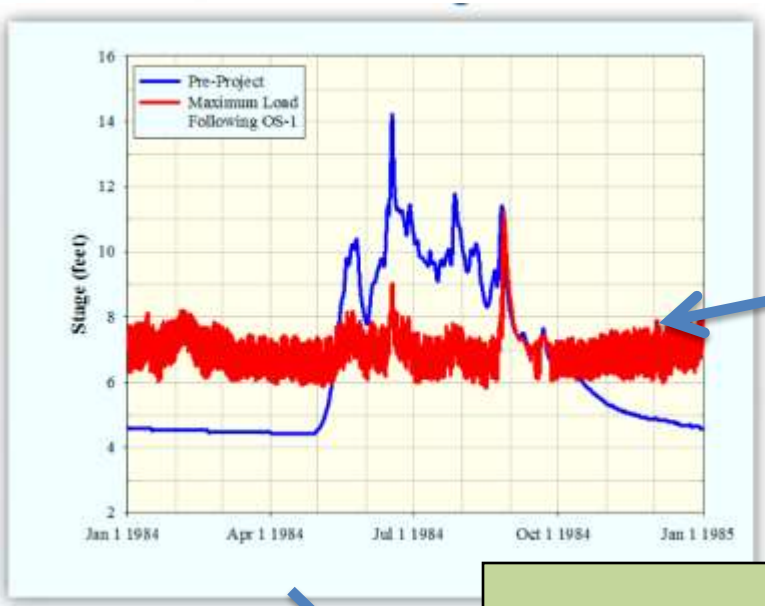
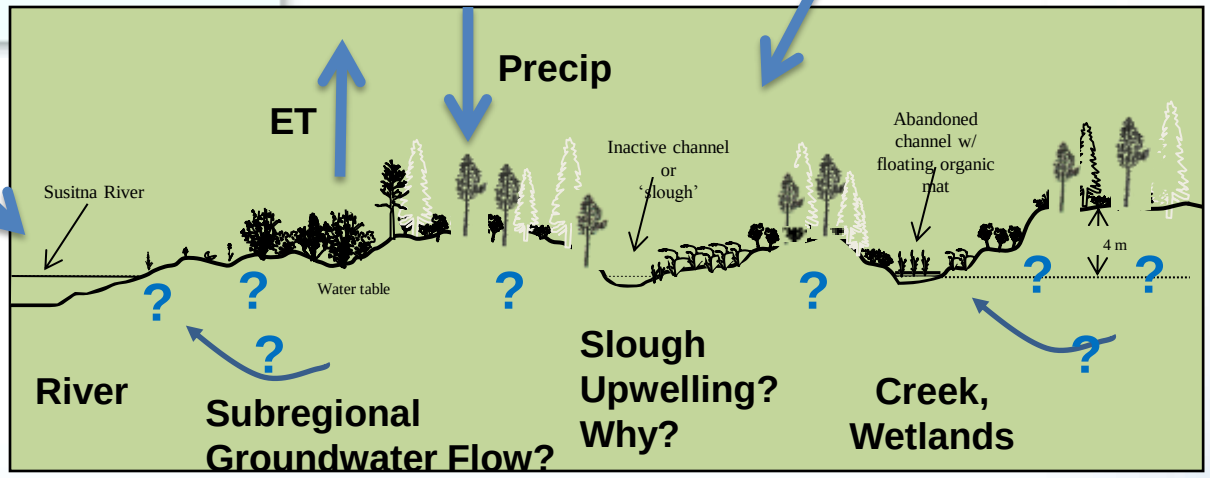
Would There Be Project Effects?



Consider These Surface Water Dynamics with the Below Environment

Project Effects?



Looking Downstream, (note: groundwater flow is not 2D)

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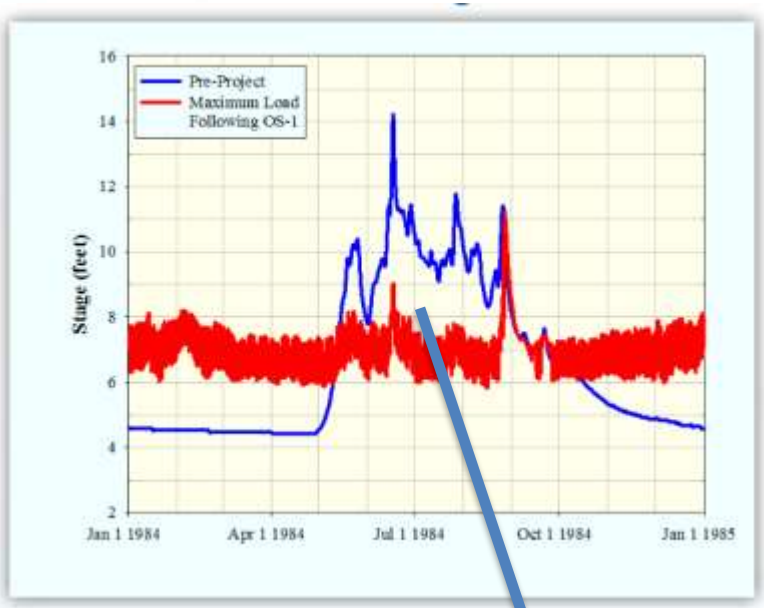

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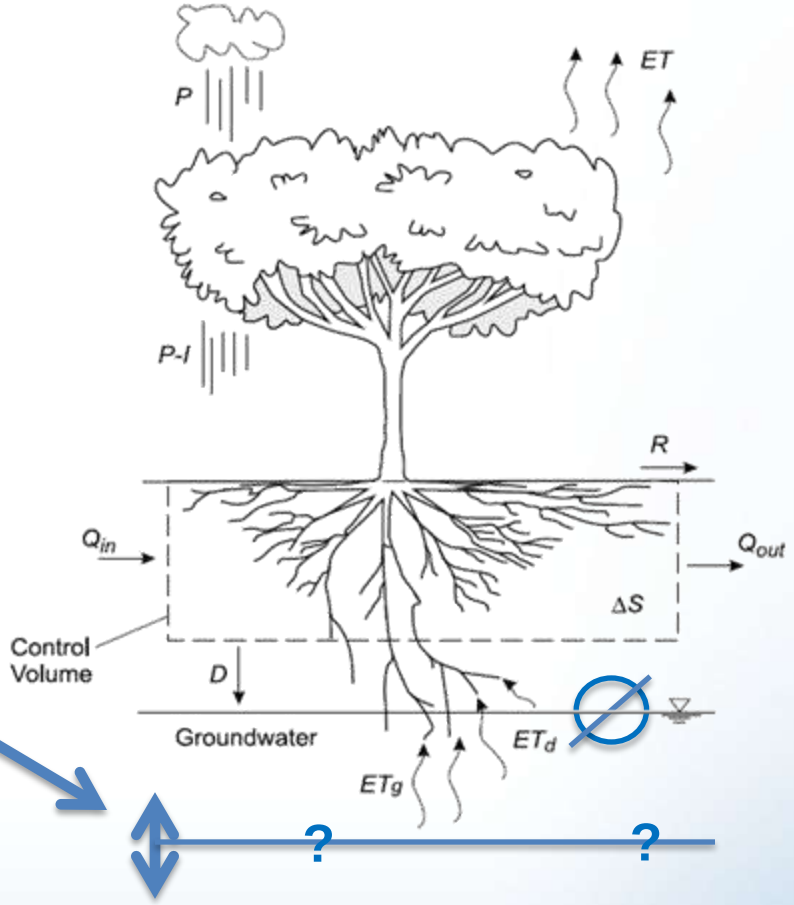

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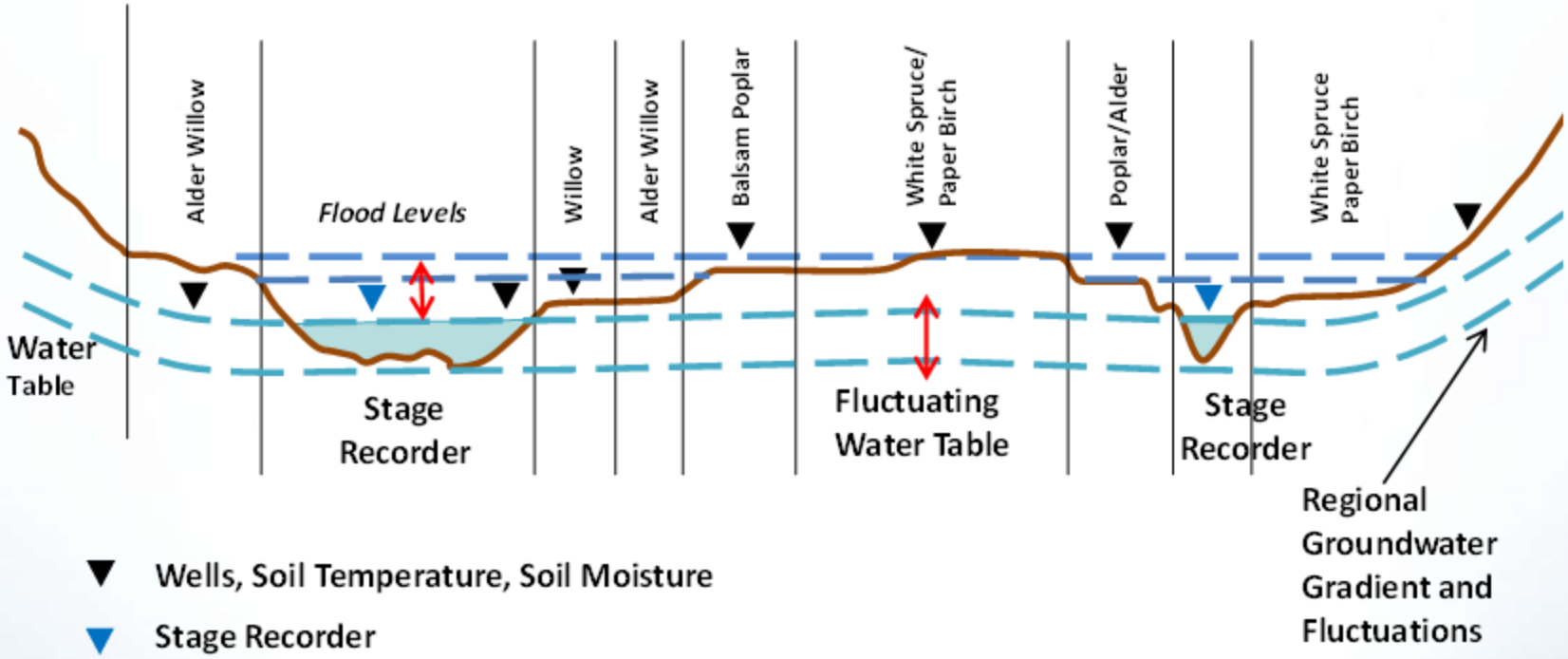
Groundwater/Surface Water Interactions Modeling



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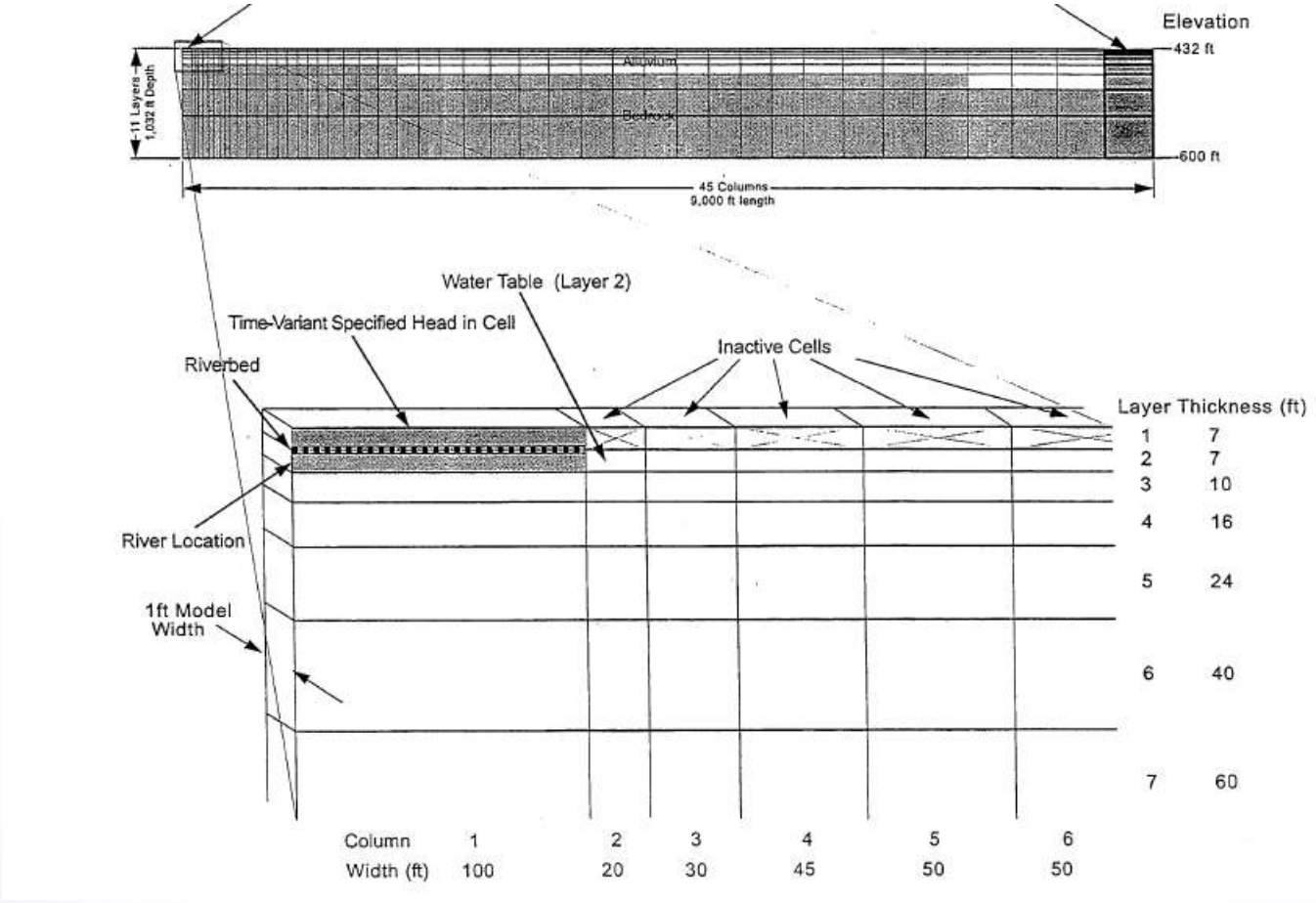
Groundwater Study Modeling

- Focus Areas with Groundwater Modeling:
  - FA104 – Whiskers Creek
    - 1 Riparian 2-D Transect Model
    - 2 Small Aquatic 2-D Transect Models
  - FA115 – Lane Creek – Slough 6A
    - 1 Riparian 2-D Transect Model

Groundwater Study Modeling

- Focus Areas with Groundwater Modeling:
  - FA128 – Skull Creek Complex – Slough 8A
    - 2 Riparian 2-D Transect Model
    - 2 Small Aquatic 2-D Transect Models
    - 1 Combined Aquatic/Riparian 3D Model
      - Key Question: What are the implications of surface-water boundaries on GW/SW interaction?
  - FA138 – Gold Creek
    - 2 Small Aquatic 2-D Transect Models

Groundwater Study Modeling



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Groundwater Study Modeling

- Major Model Inputs:
  - Main Channel/Side Channel River Stage
  - Slough/Creek Stage
  - Precipitation Recharge
  - Groundwater Boundary Conditions
  - Hydrogeologic Aquifer Properties
  - Topographic Surface and Surface-Water Features

Groundwater Study Modeling

- Modeling Timescales:
  - Transient, Annual, Multi-Year
  - Major Hydrologic Periods
    - Spring Breakup
    - Summer
    - Fall Freeze-Up
    - Winter
  - Field Data Collection Design For These Periods

Groundwater Study Modeling

- Modeling Dependencies:
  - Summer and Winter Main Channel Stage Levels
    - Open Water Flow Routing Model
      - 15 minute to daily stage data at cross-section location, or close enough to apply shifts
    - Winter Ice Processes Model
      - 15 minute to daily stage data at cross-section location, or close enough to apply shifts

Groundwater Study Modeling

- Modeling Units:
  - Stage or Water Level = Feet Above Sea Level (Project Datum Standards)
  - Flux or Discharge = Cubic Feet per Second (cfs)
  - Horizontal Coordinates = State Plain to Project Datum

Groundwater Study Modeling

- Modeling Output Units:
  - Stage or Water Level = Feet above Sea level (Project Datum Standards)
  - Flux or discharge = Cubic Feet per Second (cfs)
  - Horizontal coordinates = State Plain to Project Datum
  - Unit Conversions to SI Possible When Needed

Groundwater Study Modeling

- Modeling Output Units:
  - Stage or Water Level = Feet above Sea level (Project Datum Standards)
  - Flux or discharge = Cubic Feet per Second (cfs)
  - Horizontal coordinates = State Plain to Project Datum
  - Unit Conversions to SI Possible When Needed

Groundwater Study Modeling

- Project Effects Analysis:
  - Riparian Objectives
    - Groundwater levels, unsaturated zone fluxes
    - Response to changes in mainstem water level changes (winter and summer)
  - Aquatic Objectives
    - Changes in groundwater/surface-water conditions at each modeling transect
    - Define processes understanding to apply to non-modeled areas (analysis outside of modeling effort)

Next Steps

- Continued Empirical Data Collection
- GW/SW Process Numerical Modeling Developing Riparian MODFLOW models
- Empirical Relationship Development
- Up-scaling

FA-128 (Slough 8A), Slough 8A and Middle Side Channel 8A junction on October 29, 2013