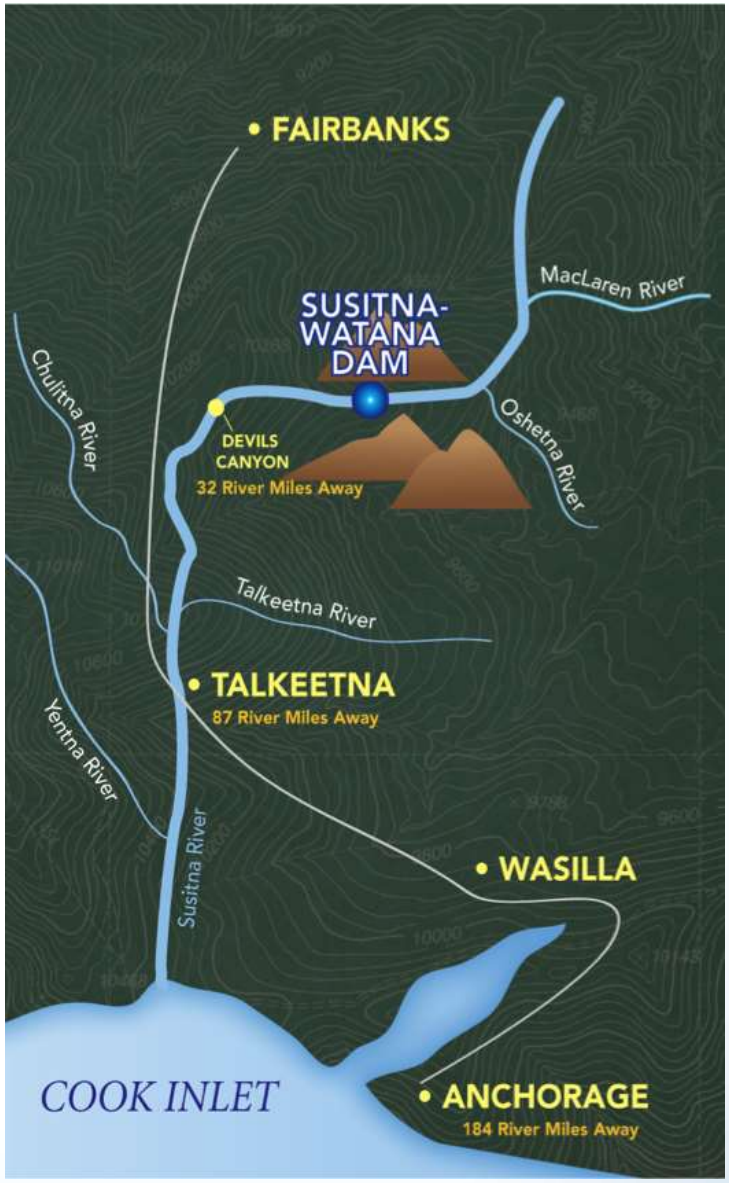
Geomorphology Studies

Technical Workgroup Meeting
June 26, 2013

Prepared by: Tetra Tech

Prepared for: Alaska Energy Authority



Presentation Topics

- Review recent activities (Q2 2013) and go over planned summer (Q3 2013) efforts
- Presentation Topics:
  - Modeling approach Tech Memo
  - Large woody debris study component
  - Reconnaissance trips / field efforts
  - USGS sediment data collection
  - Aerial photography and LiDAR

Modeling Approach Tech Memo

Modeling Approach Technical Memo: Purpose and Background

FERC SPD Recommendation 4/1/2013

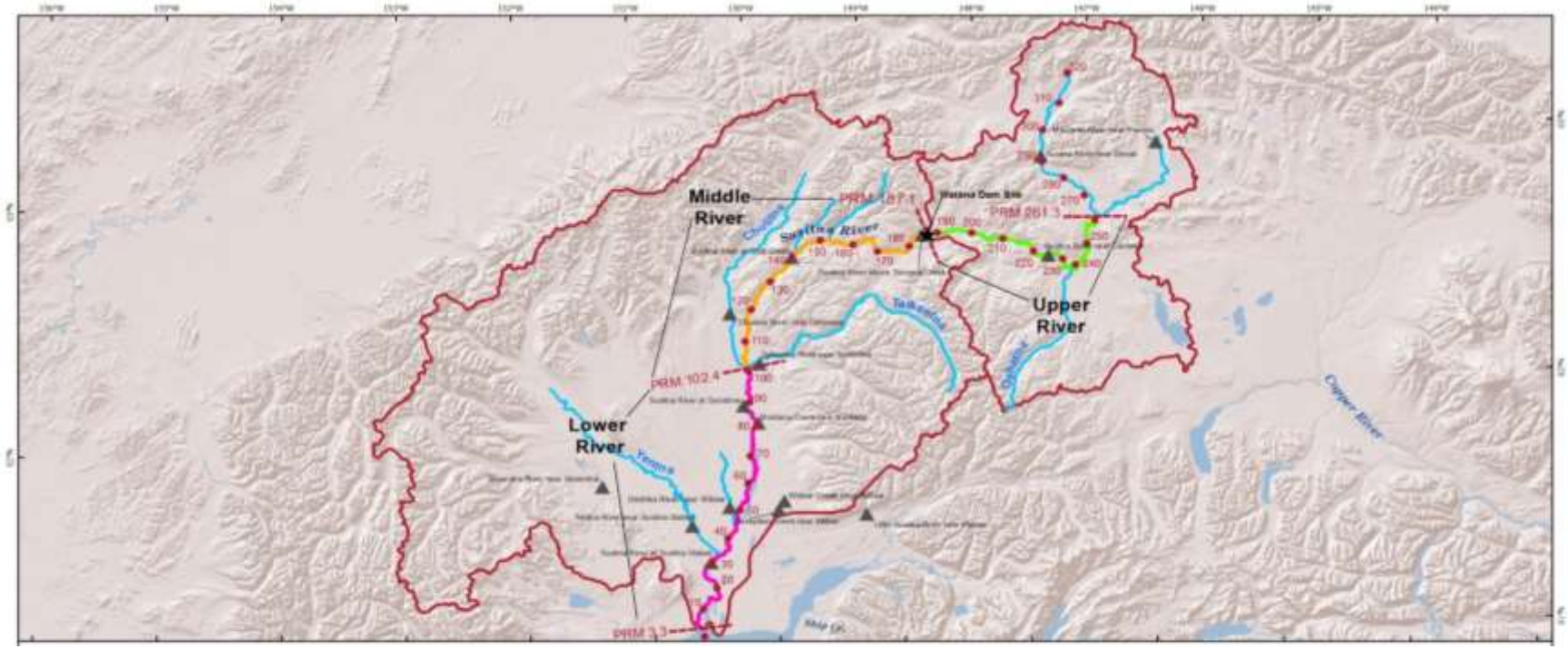
- Consult with licensing participants and file final modeling technical memo by 6/30/ 2013

- Distributed draft modeling tech memo 5/3/2013
- Received comments from NMFS 5/17/2013
- Held follow-up meeting on 5/21/2013
- Additional comments received 6/5/2013 from Becky Long, CWA, Whitney Wolf

Modeling Approach Technical Memo - Objectives

- Modeling in Focus Areas
  - Specify the 1-D and 2-D models for FGM
  - Provide rationale and criteria for model selection
  - Identify location and extent of models
  - Provide overview of model development
- Interaction at Three Rivers Confluence
  - Describe approach for evaluating geomorphic change at confluence of Susitna, Chulitna, and Talkeetna Rivers
- Incorporating LWD and Ice Processes
  - Describe approaches for 1-D and 2-D modeling

Model Scale and Extents



- Reach-Scale 1-D Modeling
  - Long time periods (decades)
  - Conditions along river (10^{1} – 10^{0} x width)
  - Conditions over subareas (channel, L/R , FP
- Local-Scale 2-D Modeling
  - Short time periods (< 1 year)
  - Conditions in river (10^{0} – 10^{-1} x Susitna width)
  - In side channels (10^{-1} – 10^{-2} x width)
  - In floodplains and islands (10^{0} – 10^{-1} x width)

Model Selection: Criteria

- 1-D and 2-D model requirements
  - Sufficient number of sediment sizes
  - Computes transport by size fraction (armoring and sorting)
  - Includes Wilcock & Crowe or Parker transport relations
  - Only public domain and commercial models considered
- 1-D model requirements
  - Large Extent (number of cross sections)
  - Long Duration (number of hydrograph ordinates)
  - Closed loop transport (split flow around islands)
- 2-D model requirements
  - Detailed spatial resolution (large number of elements)
  - Flexible (irregular) mesh

Model Selection: 1-D

- HEC-RAS version 4.1 (USACE)
  - Eliminated: no closed loop capability
- SRH-1D version 2.8 (USBR)
  - Meets requirements but not selected
  - Disadvantages: limited use, no GUI, potential limitation on number of sediment size classes
  - Advantage: fully unsteady
- MIKE 11 version 2011 (DHI)
  - Eliminated: Does not include required transport relations
- ***HEC-6T version 5.13.22-08 (MBH)***
  - Selected – meets requirements
  - Advantages: widespread use and modeling team experience
  - Disadvantages: quasi-unsteady, basic GUI

Model Selection: 2-D

- MIKE 21 version 2011 (DHI)
  - Eliminated: Does not include required transport relations
- ADH version 4.3 (USACE)
  - Eliminated: Does not include required transport relations
- MD_SWMS-SToRM (USGS)
  - Eliminated: Does not currently include sediment transport
- RiverFLO-2D version 3 (Hydronia LLC)
  - Eliminated: single sediment size & lacks required sediment transport relations
- ***SRH-2D version 3 (USBR)***
  - Still candidate: Meets requirements
- ***River2D (R2DM) (U. Alberta & U. British Columbia)***
  - Still candidate: Meets requirements

Comprehensive Modeling Approach

1-D Reach-Scale Morphology Models

Hydro. & Sed. input: Existing & 3-OS – continuous 50-year simulations

	Year 0	Year 25	Year 50
Geometry:	Existing	"Existing" & 3-OS	"Existing" & 3-OS

Provides Yr-25 & 50 sediment inflow, geometry and d/s rating curves

2-D Morphology Unsteady Models at FAs

~6 month simulations for Yr-0, 25 & 50

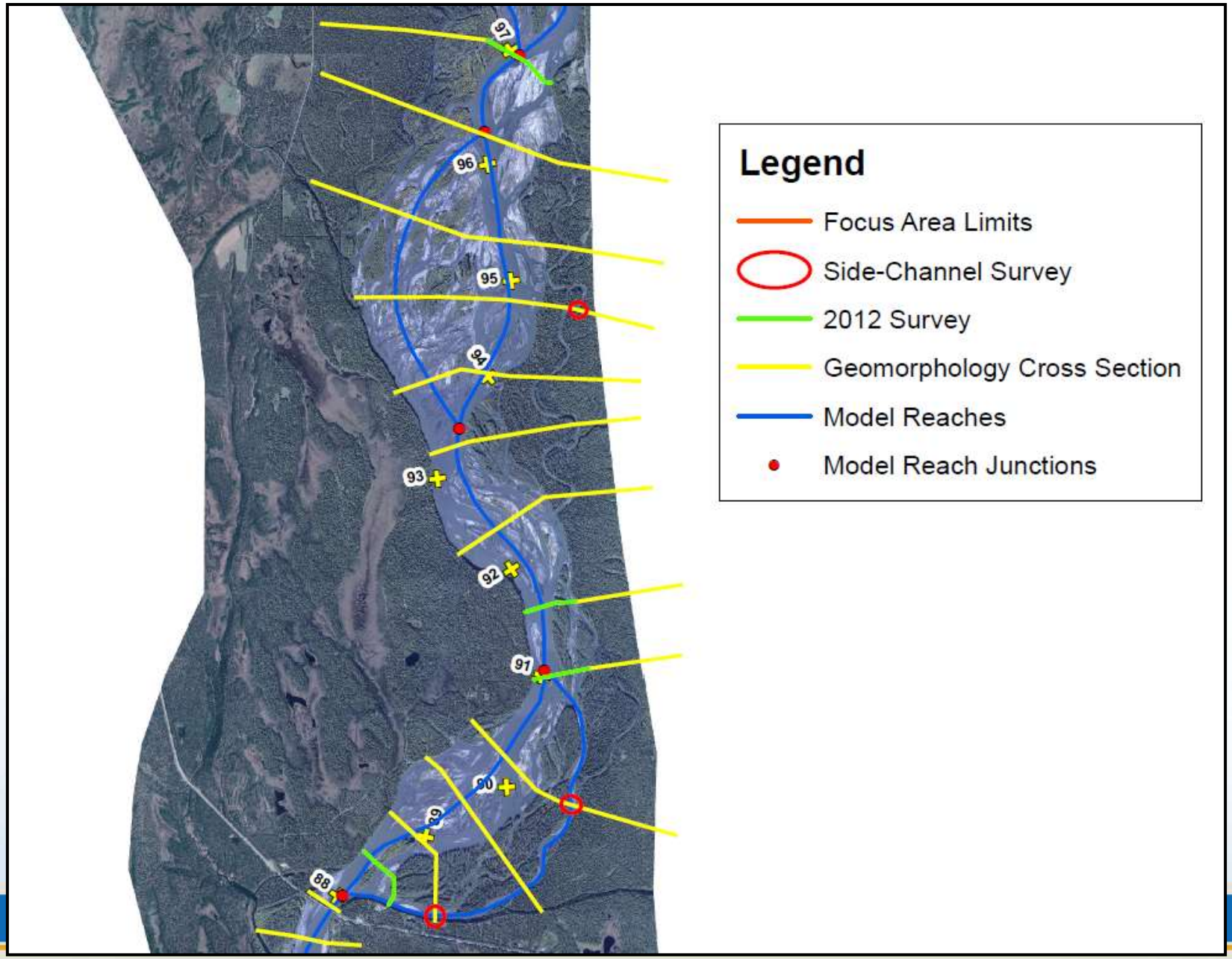
Provides input on Yr-25 & 50 substrate & lateral feature geometry

2-D Hydraulic (habitat) Steady Models at FAs

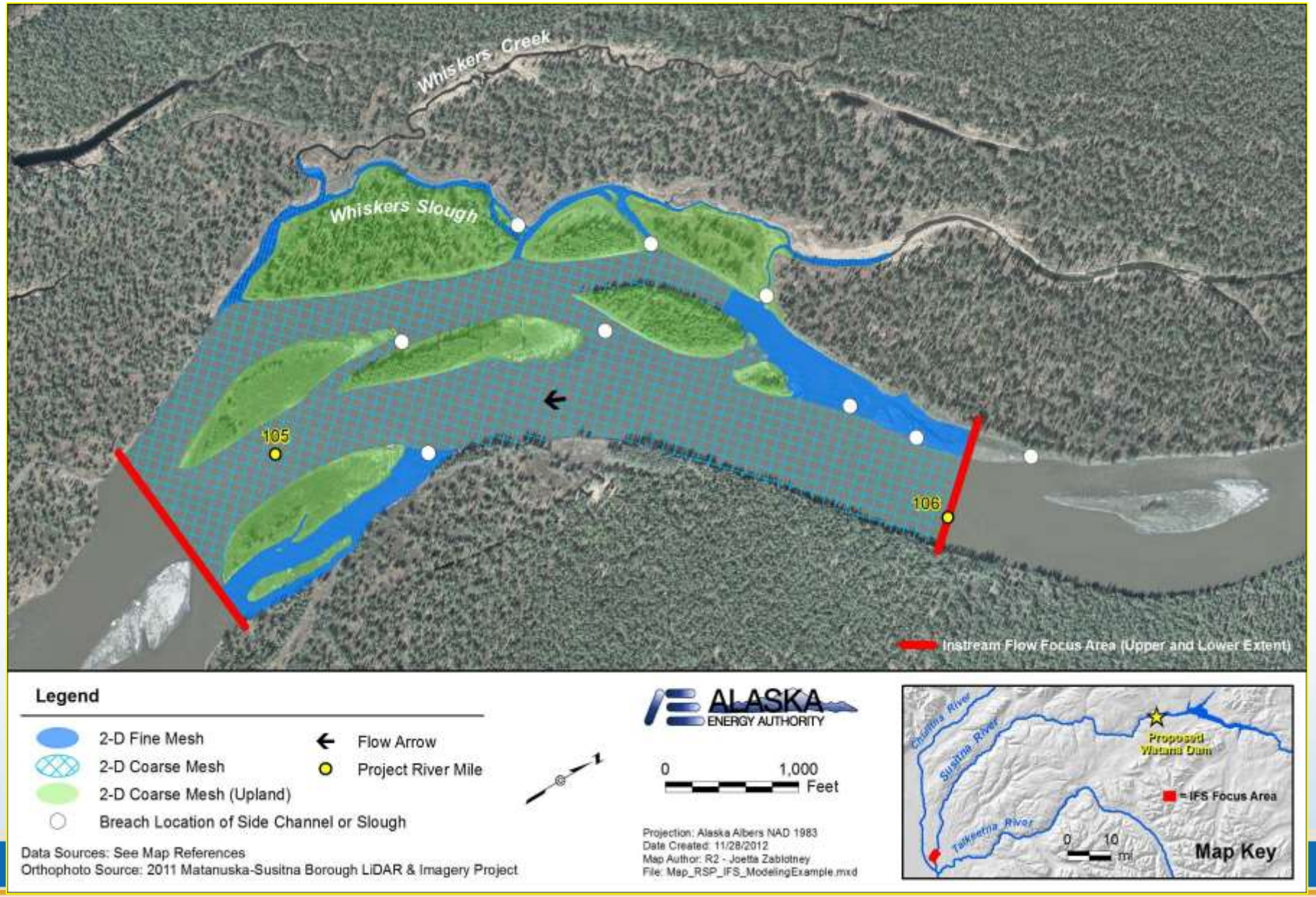
	Year 0	Year 25	Year 50
Geometry:	Existing	"Existing" & 3-OS	"Existing" & 3-OS

Provides hydraulic data to habitat models for range of flows.

1-D Model Example Cross Sections



2-D Models (10 Focus Areas)

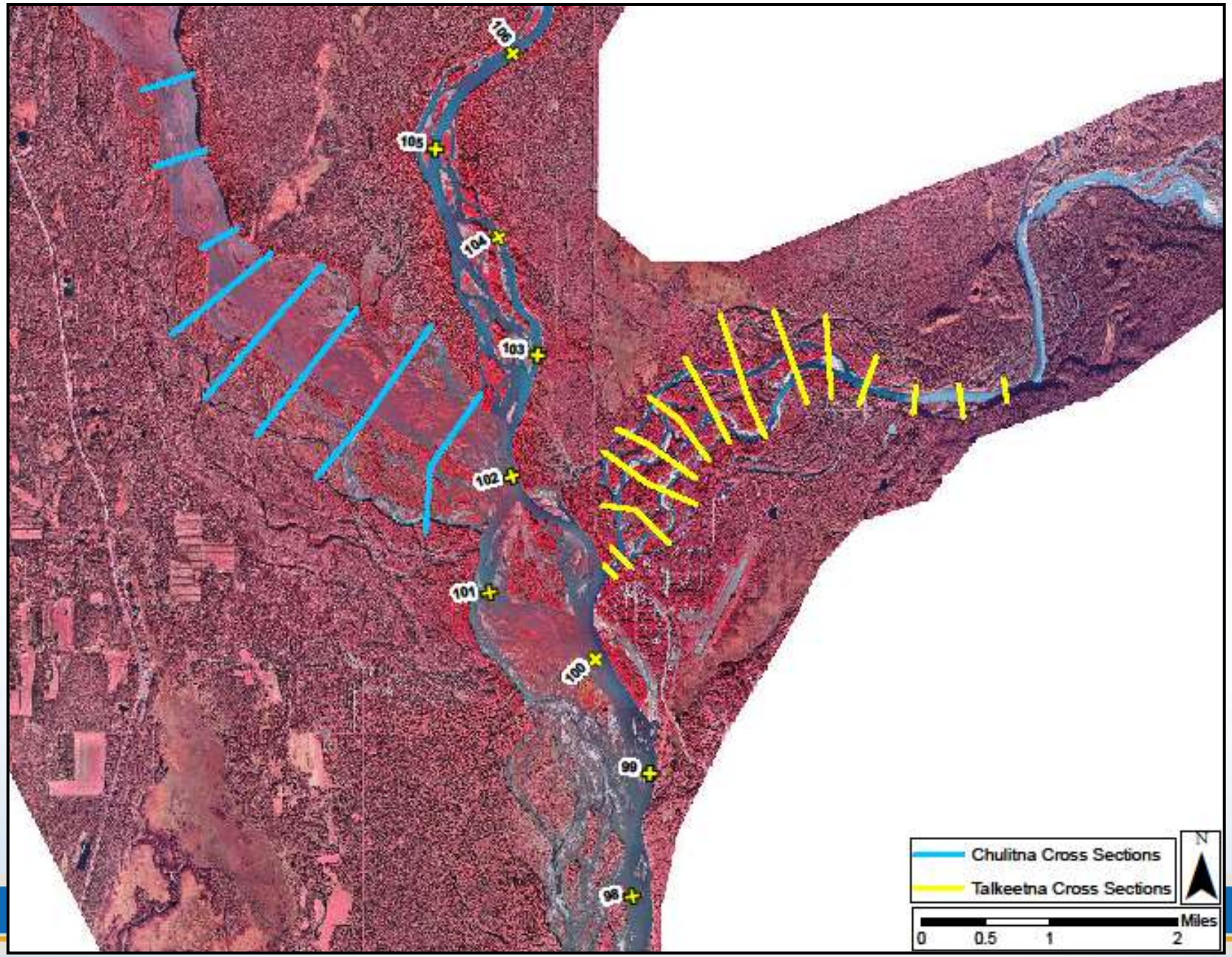


Three Rivers Confluence Modeling: Objectives

- Chulitna and Talkeetna Rivers included in 1-D models to evaluate geomorphic change at Three Rivers Confluence

- Compare existing conditions to with-Project to evaluate
  - Hydraulic interactions
  - Sediment transport interactions
  - Channel change

1-D Model: 3 Rivers Confluence

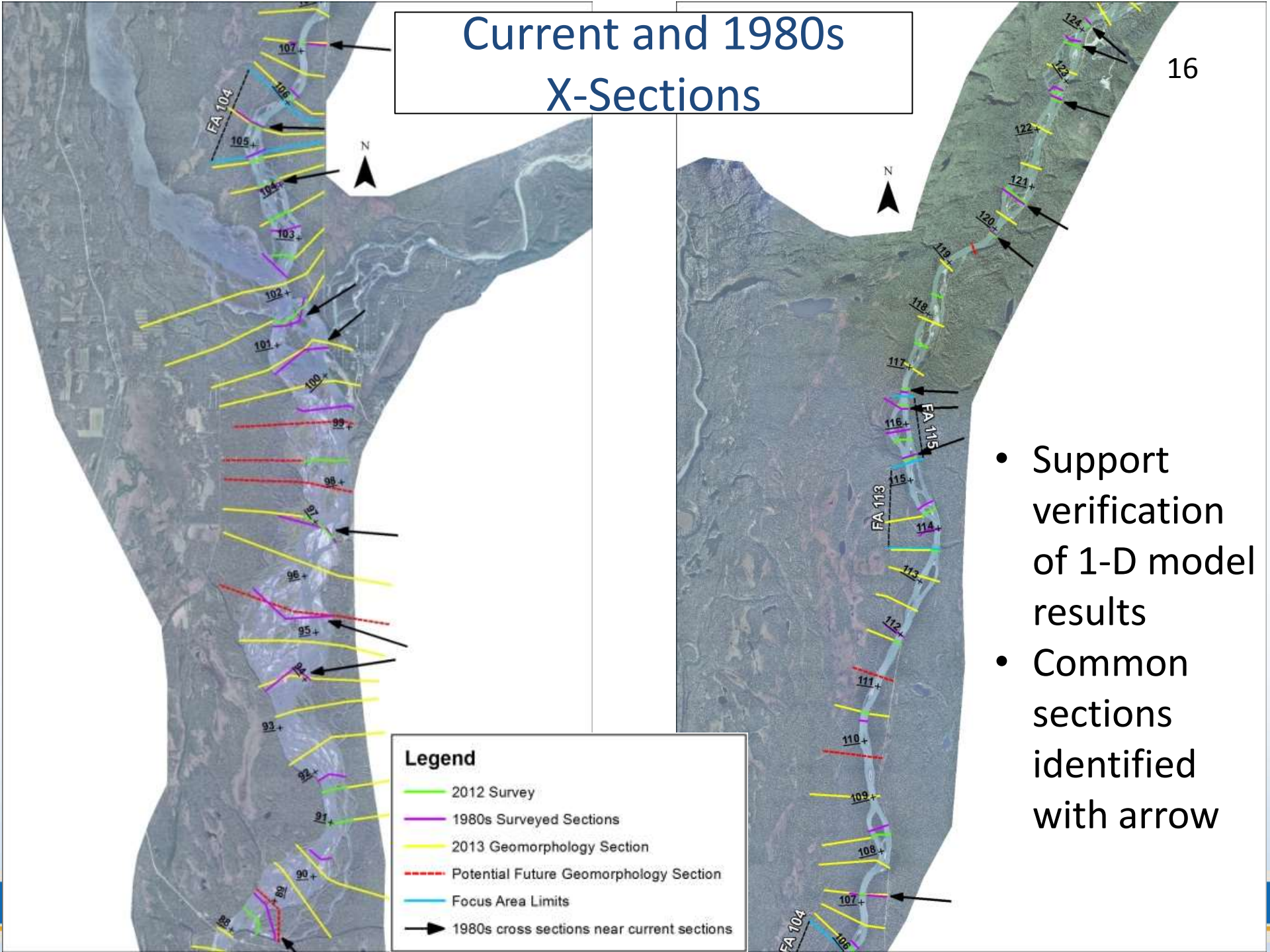


Tributary Models

- Middle River Focus Areas
  - Sediment input to 1-D and 2-D models
  - Tributary delta modeling
- Lower River
  - Sediment input to 1-D models
  - 1-D tributary conditions
- Middle River sediment only
  - Sediment input to 1-D models

Tributary Name	PRM	Entering Bank	Geomorphic Reach	Focus Area	Sediment Input only	1-D or 2-D
Tsusena Creek	184.6	RB	MR-2		X	1-D
Fog Creek	179.3	LB	MR-2		X	1-D
Unnamed	174.3	LB	MR-2	FA173		2-D
Unnamed	173.8	RB	MR-2	FA173		2-D
Portage Creek	152.3	RB	MR-5	FA151		2-D
Unnamed	144.6	LB	MR-6	FA144		2-D
Indian River	142.1	RB	MR-6	FA141		2-D
Gold Creek	140.1	LB	MR-6		X	1-D
Skull Creek	128.1	LB	MR-6	FA128		2-D
Lane Creek	117.2	LB	MR-7		X	1-D
Unnamed	115.4	RB	MR-7	FA115		2-D
Gash Creek	115.0	LB	MR-7	FA113		2-D
Slash Creek	114.9	LB	MR-7	FA113		2-D
Unnamed	113.7	LB	MR-7	FA113		2-D
Whiskers Creek	105.1	RB	MR-8	FA104		2-D
Trapper Creek	94.5	RB	LR-1			1-D
Birch Creek	92.5	LB	LR-1			1-D
Sheep Creek	69.5	LB	LR-2			1-D
Caswell Creek	67.0	LB	LR-2			1-D
Deshka River	45.0	RB	LR-3			1-D

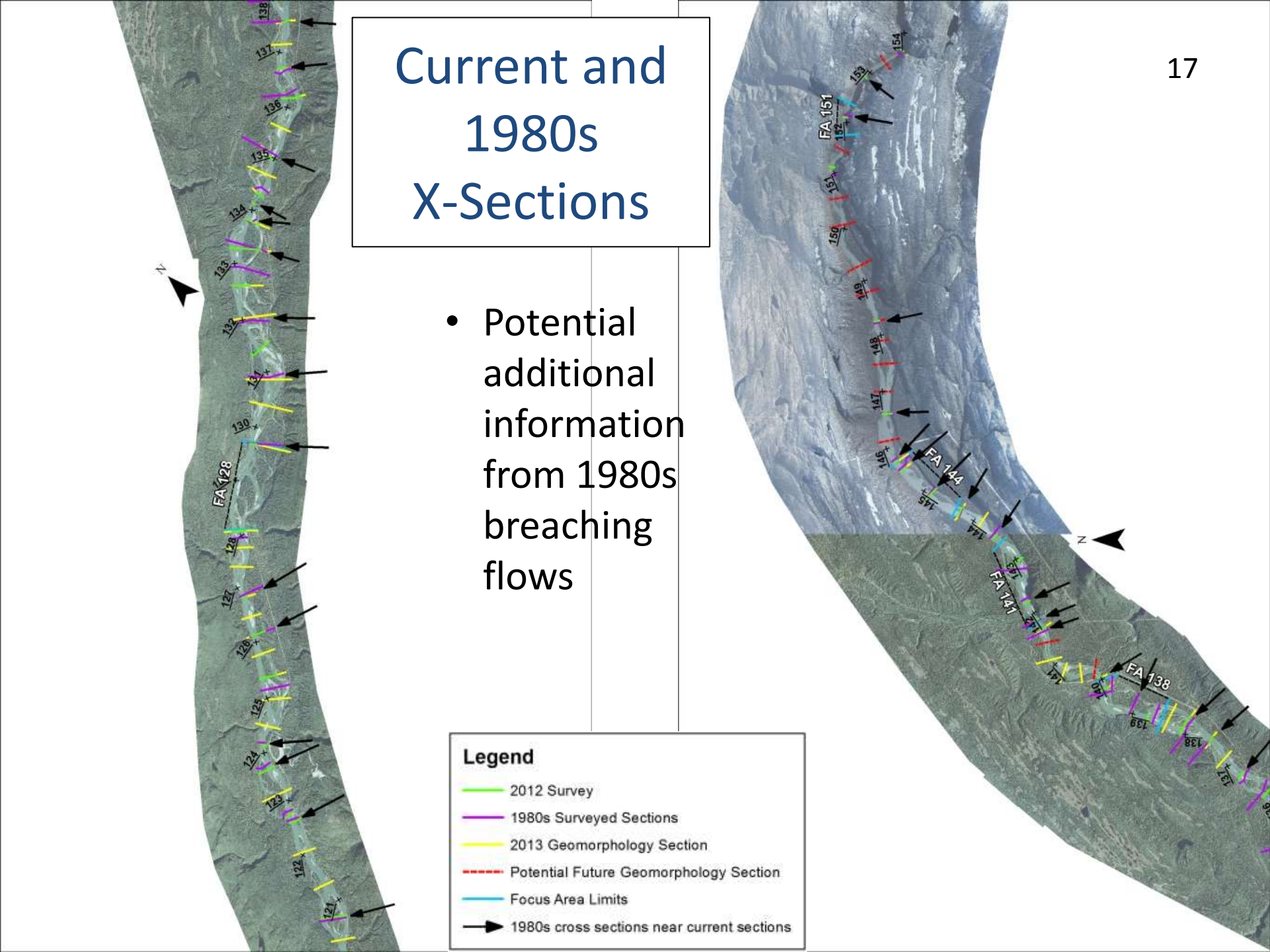
Current and 1980s X-Sections



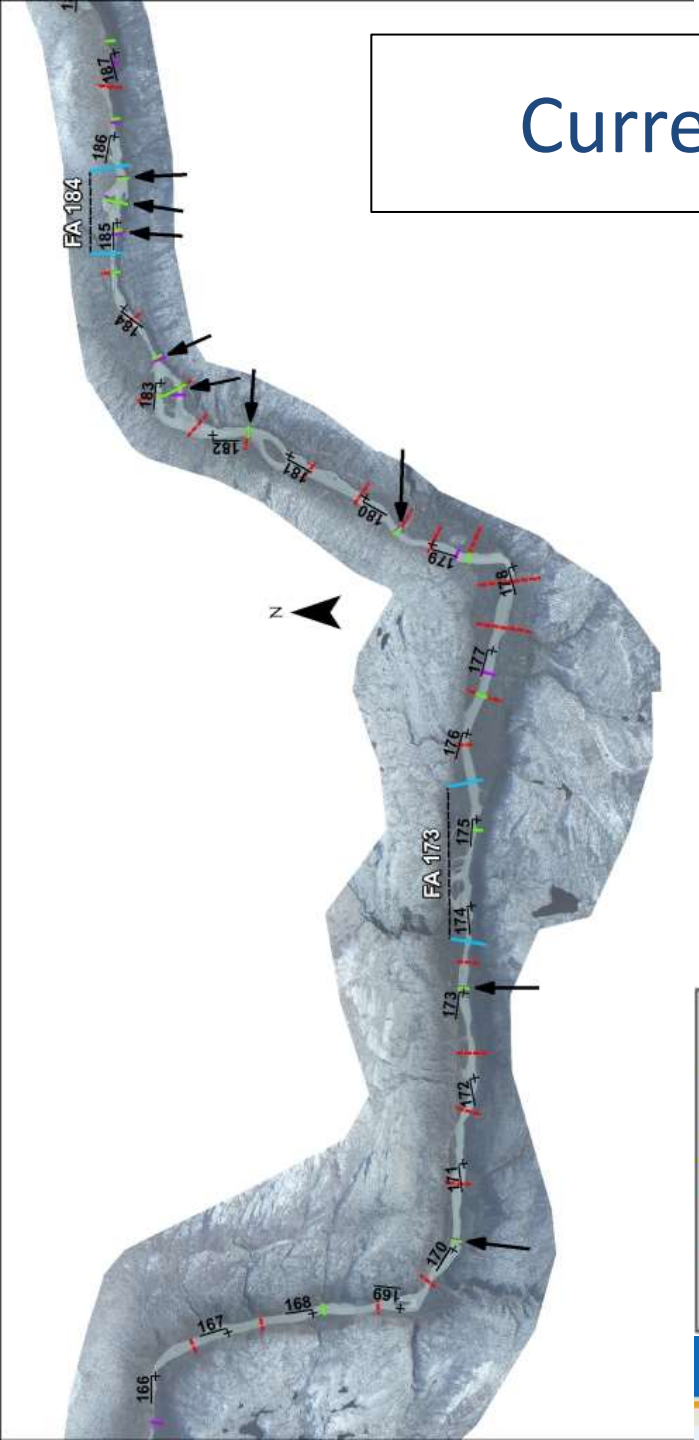
- Support verification of 1-D model results
- Common sections identified with arrow

Current and 1980s X-Sections

- Potential additional information from 1980s breaching flows



Current and 1980s X-Sections



- Total number of common 1980s and present cross sections - 53:
  - MR = 47
  - LR = 6
- By geomorphic reaches:
  - MR-1 = 4 , MR-2 = 0
  - MR-3 = 0 , MR-4 = 0
  - MR-5 = 2, MR-6 = 26
  - MR-7 = 6, MR-8 = 3
  - LR-1 = 6

Legend

- 2012 Survey
- 1980s Surveyed Sections
- 2013 Geomorphology Section
- Potential Future Geomorphology Section
- Focus Area Limits
- 1980s cross sections near current sections

Large Woody Debris Study Component

Large Woody Debris

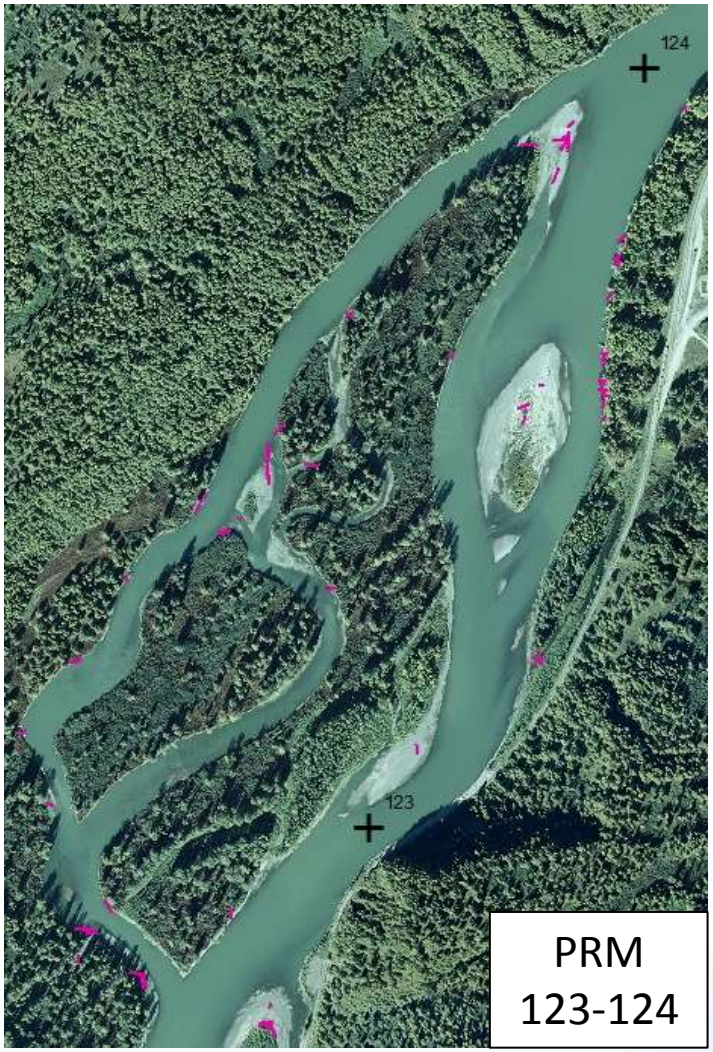
Whiskers Slough Focus Area (example)

- Currently digitizing large woody debris from 2012 aerial photographs:
  - All wood over 20 feet long in channel, side channel, and slough geomorphic units
  - Sub-sample wood on Bar Island Complexes in Lower River to determine wood density
  - Attributes: Root wad, Channel position, Local source
  - Log jams
- Will compare wood from 1950, 1980, 2012, and planned 2013 (post flood) aerials in selected locations to assess wood mobility

Initial Observations

Wood generally more abundant in complex channel areas

PRM 109-110



PRM 123-124

Wood Digitized to Show Orientation with Flow, Root Wad End

2013 Large Woody Debris Field Work

- Objectives are to field verify aerial photograph mapping and provide input to geomorphic and fisheries modeling efforts
- Will cover all Focus Areas and 20 additional areas distributed throughout Lower, Middle, and Upper River (mouth to Maclaren River)
- GPS all wood (over 20 feet long) and jams
- Collect attribute data including:
  - Orientation
  - Size class (based on length, diameter)
  - Root wad
  - Decay class
  - Species and input mechanism if known
  - Channel location
  - Function
  - For log jams: key piece size(s), dimensions of jam

Site Reconnaissance and Field Work

2013 Site Reconnaissance:

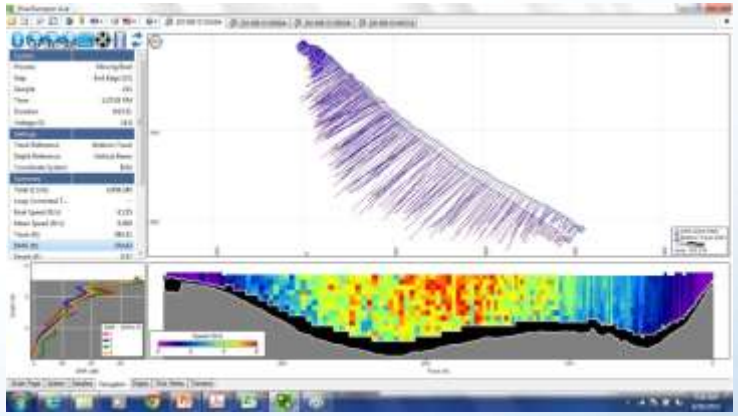
May 14-17 and June 13-14

May 14-17, 2013 Site Reconnaissance

- During break-up
- Grounded 16/17
- Coord. other studies
- Bed mat. LR
- LWD LR
- Refined bed sampling

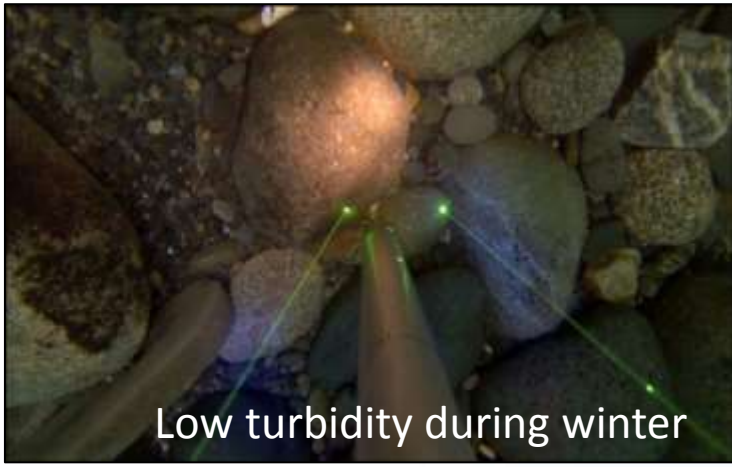
June 13-14 & 19-20, 2013 Site Reconnaissance

- Interacted with cross section survey and habitat transect survey crew in LR
- Observed tributary mouths in MR and LR
- Observed FAs in MR
- Flew aerial recon to view effects of break-up
- Interacted with FA bathy and topo survey crew



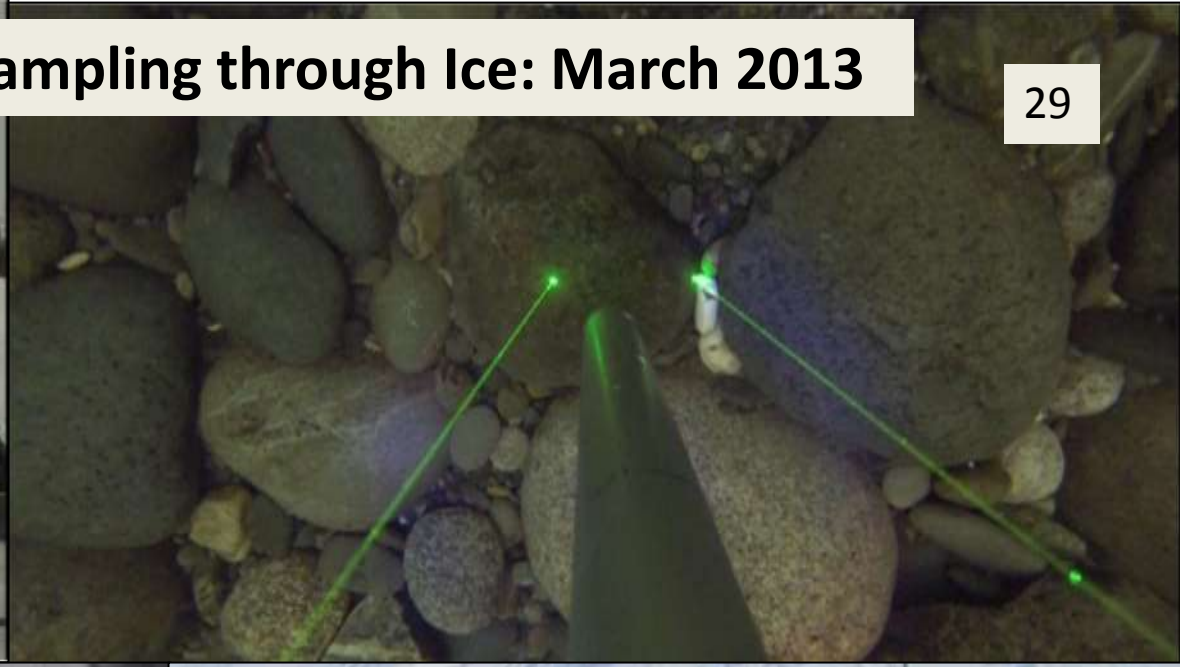
Bed Material Sampling through Ice: Why?

- Objective: Determine feasibility of sampling bed materials size distribution through ice cover
  - High turbidity most of open water period
  - Too deep and material too large to obtain physical sample
  - Low turbidity during winter provides opportunity


Low turbidity during winter

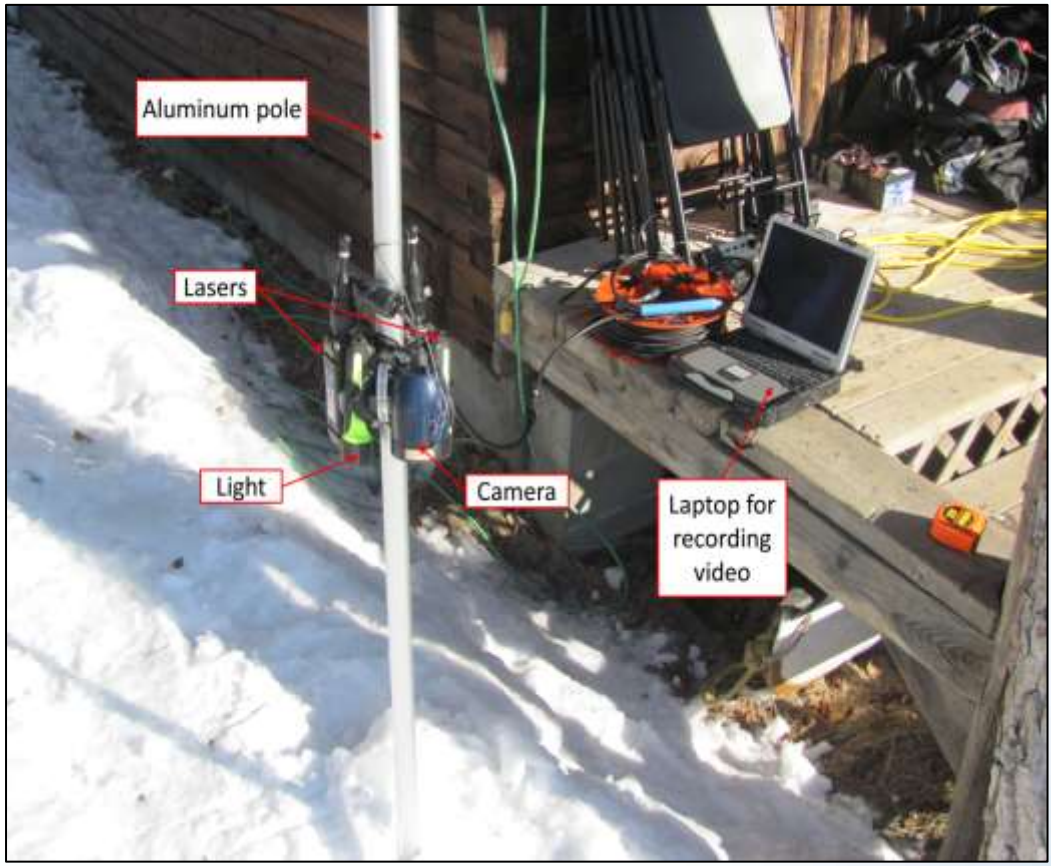

High turbidity ice free period

Bed Material Sampling through Ice: March 2013



Bed Material Sampling through Ice Conclusions

- Test shows it is feasible
- Will require several times more effort than conventional
- Potential open water opportunity before winter



Q3 2013 Field Activities: 1-D Modeling (Reach Level)

- Bed material sampling MR, LR and tribs
- Cross section surveys MR, LR and tribs
- Water surface elevation surveys cross sections
- Cross section observations

Q3 Field Activities: 1-D Modeling (Reach Level - Continued)

- 2013 MR work limited to PRM 146 and downstream
  - Due to ANCSA lands access issues
  - Remaining work will be performed in 2014
- LR tribs in 2013 are Trappers, Birch & Deshka
  - Sheep and Caswell in 2014
  - Need for additional LR tribs will evaluated in Q1 2014

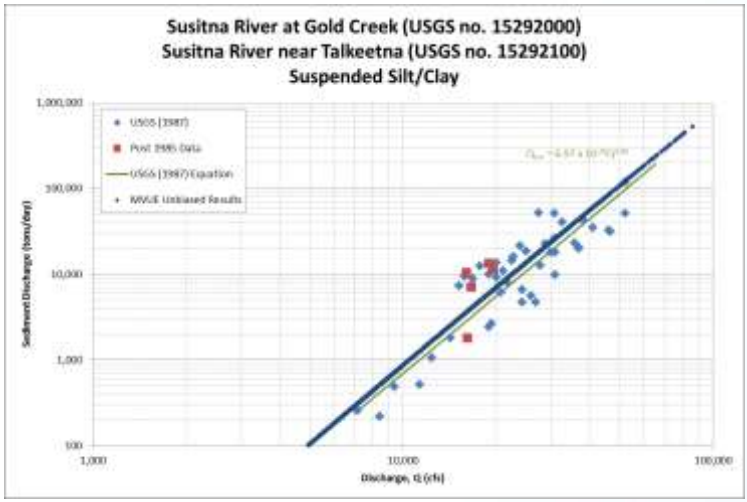
Q3 Field Activities: 2-D Modeling (Focus Areas)

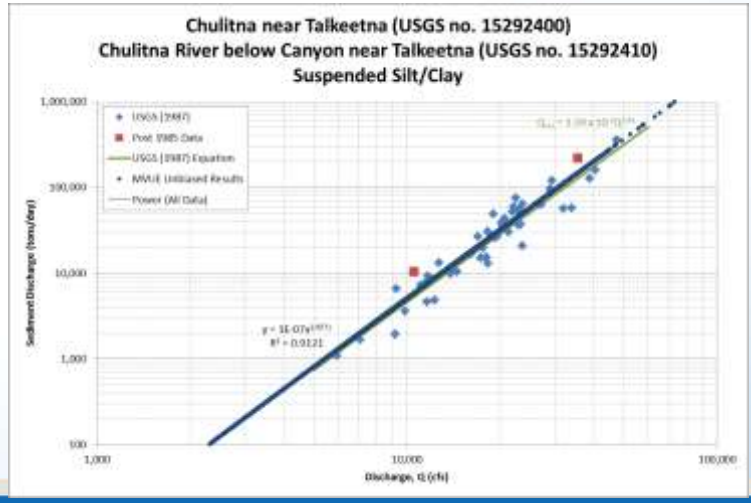
- Bed and bank material sampling Focus Areas
- Bathymetric survey
- Topographic survey
- Geomorphic assessment/observations
- Work limited to PRM 146 and downstream (7 out of 10 Focus Areas)
  - Work for 3 remaining Focus Areas (ANCSA lands) will be performed in Q3 2014
  - Initial models developed Q1 2014

USGS Sediment Transport Data Collection

USGS Sediment Data Collection: 2012 Efforts

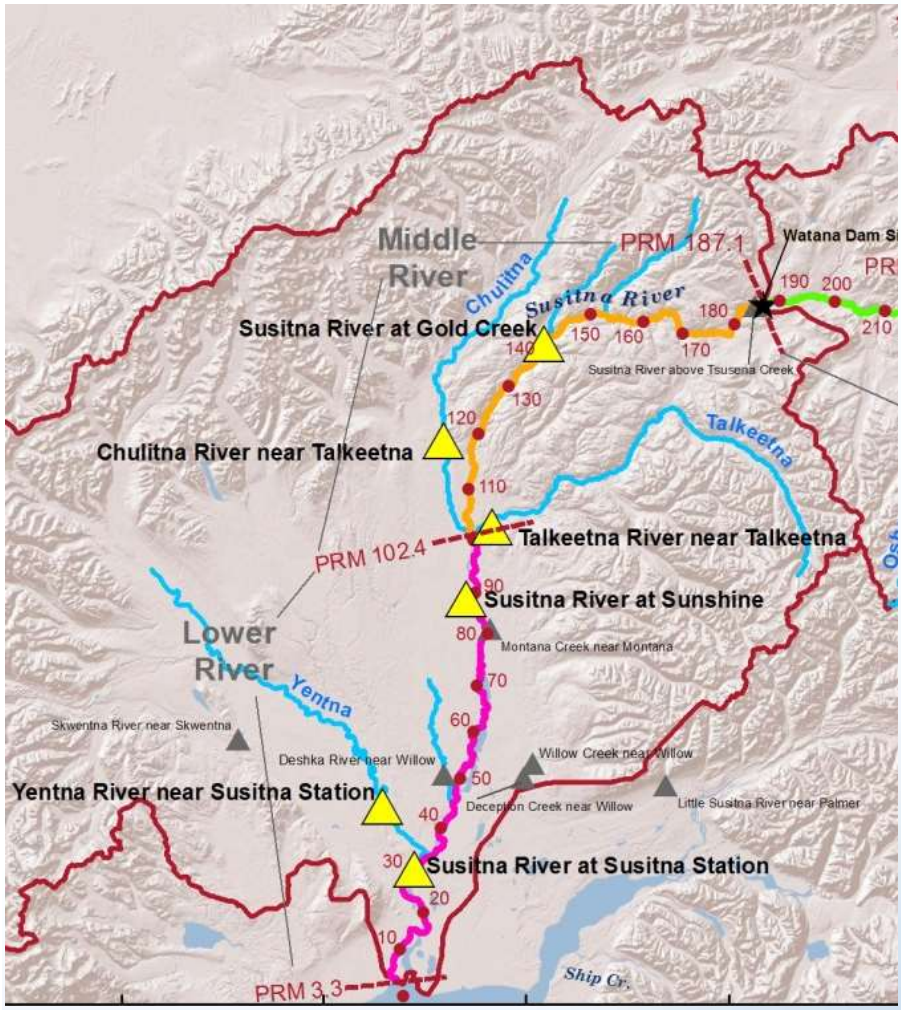
- Locations:
  - Susitna River @ Tsusena Creek, Gold Creek and Sunshine
  - Chulitna River near Talkeetna
- Data collected:
  - Discharge, stage, temperature and turbidity
  - Suspended sediment, bedload & bed material
- Status: data being analyzed by USGS – Draft report submitted





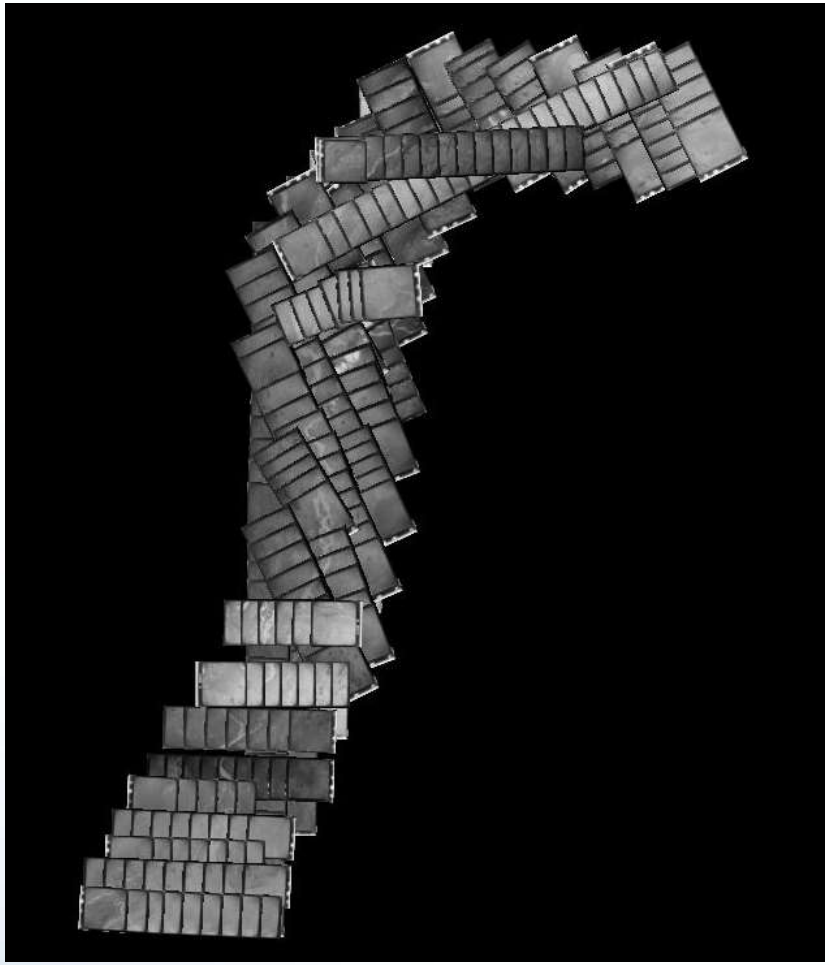
USGS Sediment Data Collection 2013 Efforts

- Locations: Retain original 4 stations & add:
  - Susitna River at Susitna Station
  - Talkeetna River near Talkeetna
  - Yentna River nr. Susitna Sta.
- Same parameters as 2012
  - 5 flows
  - Bed load for Susitna at Tsusena dropped due to safety & logistics



Aerial Photos and LiDAR

1950s Aerials: 1949 - 1954 Aerial Tiles

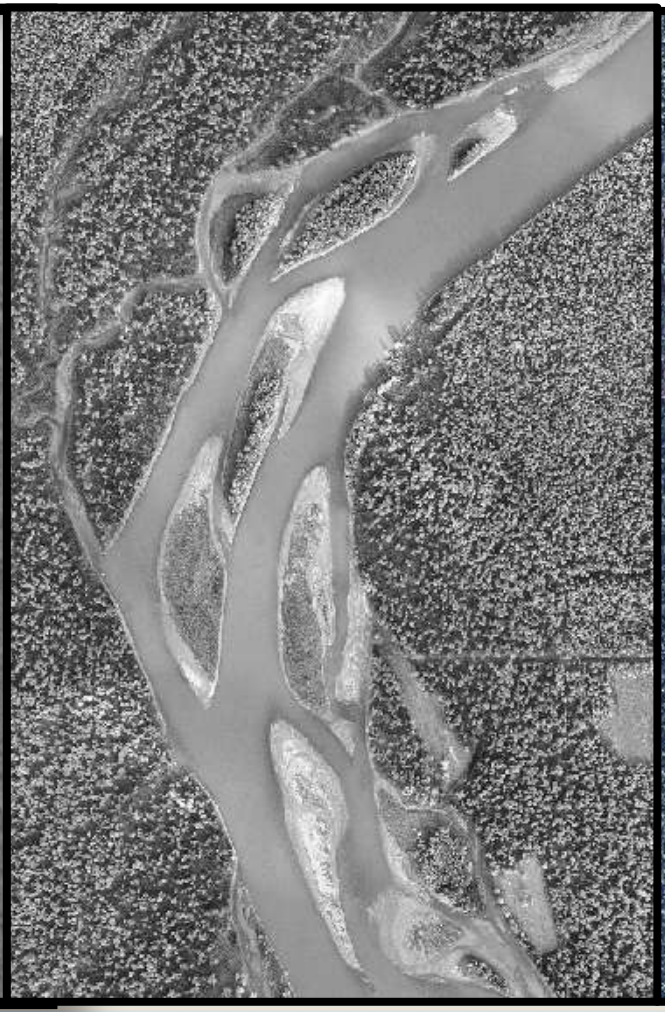


- Image: Block of 400 archival photographs identified using the USGS Earth Explorer website. Based on initial estimates that will be refined as work of controlling the block proceeds (i.e., processing the aerials).
- Medium resolution scans downloaded (and displayed). High Resolution scans on order. Final orthophotos will be produced from the high resolution scans.
- Dates of aerials: August 1949 to July 1954.
- Nominal Scales: 1:40,000 to 1:50,000

Temporal Aerials of Whiskers Slough (PRM 104 – PRM 106)

May 25, 1951
8,810 cfs @ Gold Creek

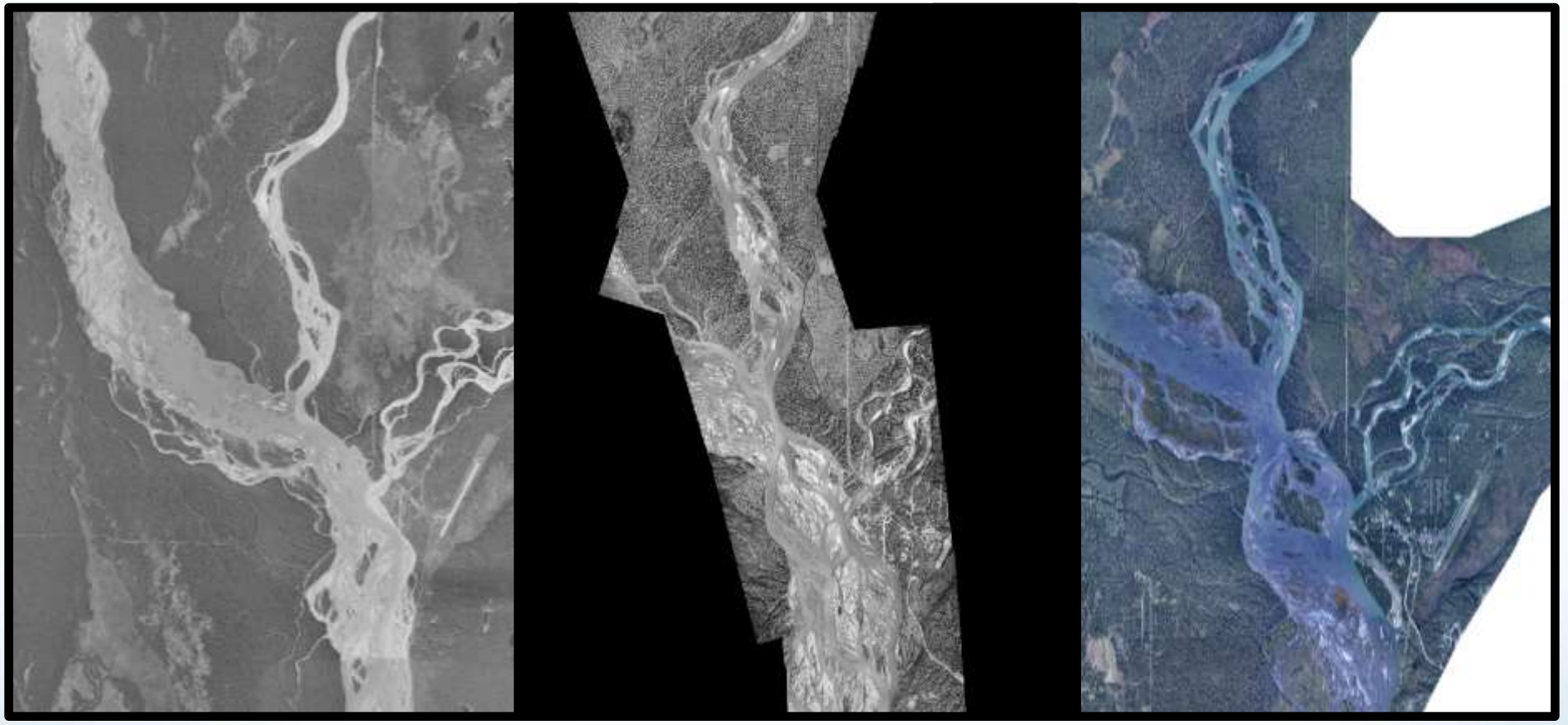
September 11, 1983
12,200 cfs @ Gold Creek



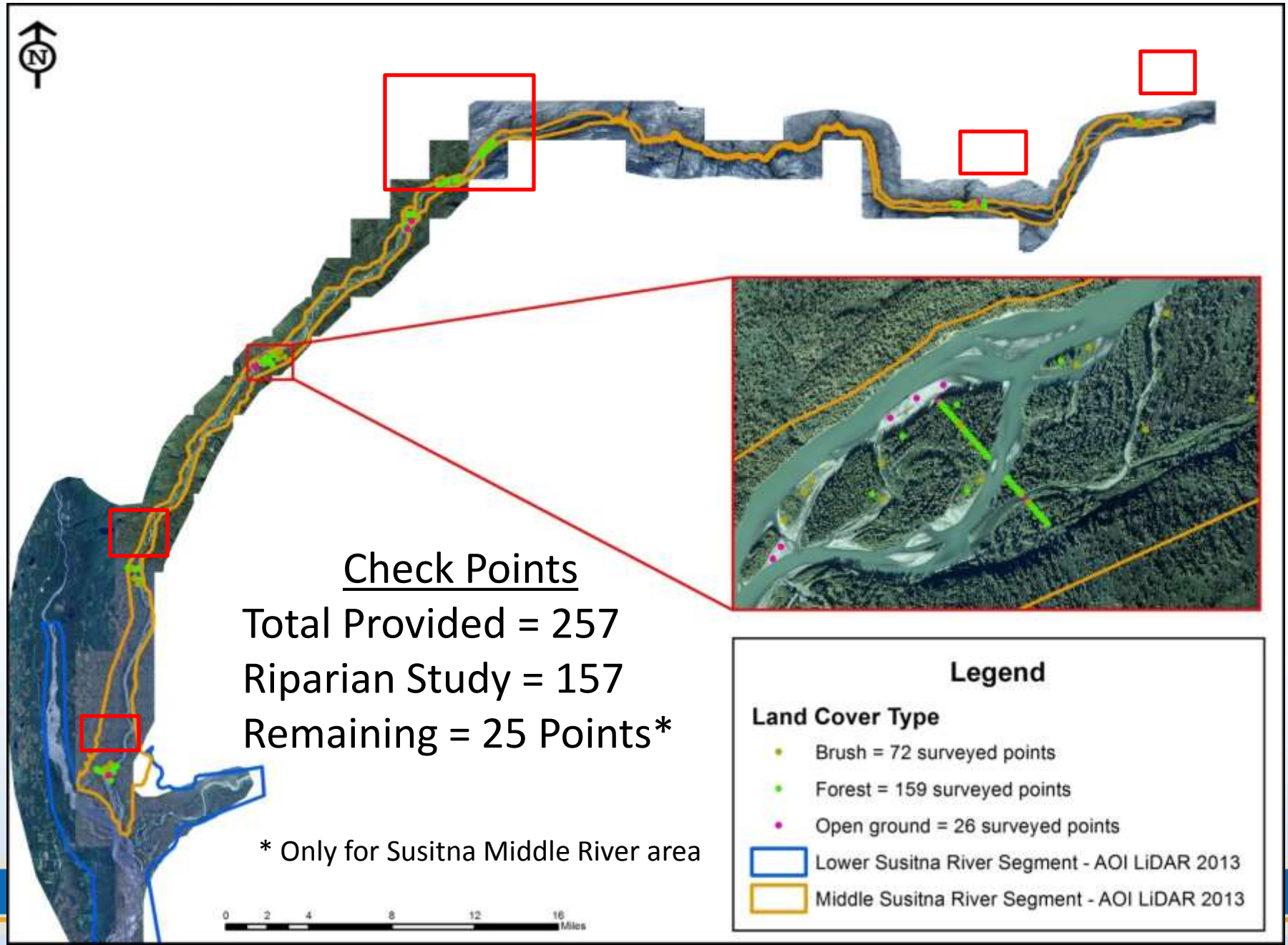
September 10, 2012
12,900 cfs @ Gold Creek

Temporal Aerials of Three Rivers Confluence (PRM 100 – PRM 103)

May 25, 1951	September 11, 1983	September 10, 2012
8,810 cfs @ Gold Creek	12,200 cfs @ Gold Creek	12,900 cfs @ Gold Creek
49,300 cfs @ Sunshine	28,000 cfs @ Sunshine	37,900 cfs @ Sunshine



LiDAR Verifications: Land Survey Check Points by Cover Type Map



LIDAR VERTICAL ACCURACY TESTS: Verification Methodologies

- Based upon **standard specifications by FEMA** (*procedure memorandum no 61, September 27 2010*) and **ASPRS** (*vertical accuracy reporting for LiDAR data, May 24 2004*)
- Determining and statistical analysis of the elevation differences: bare-earth LiDAR model of MSB 2011 vs. land surveyed check points 2013
- Land surveyed check points were established per each major land cover present in the Middle Susitna River area:

  1) OPEN TERRAIN = 26, 2) FOREST LAND = 159 , 3) BRUSH LAND = 72

- According to FEMA PM no 61 and ASPRS, *"vertical accuracy is defined as the positional accuracy of a dataset with respect to a vertical datum",* it is expressed as the quantity of error at the 95% of confidence level (95th percentile), and it is obtained by the following formula:

  ACCURACY(Z) = RMSE(Z) x 1.96 in centimeters

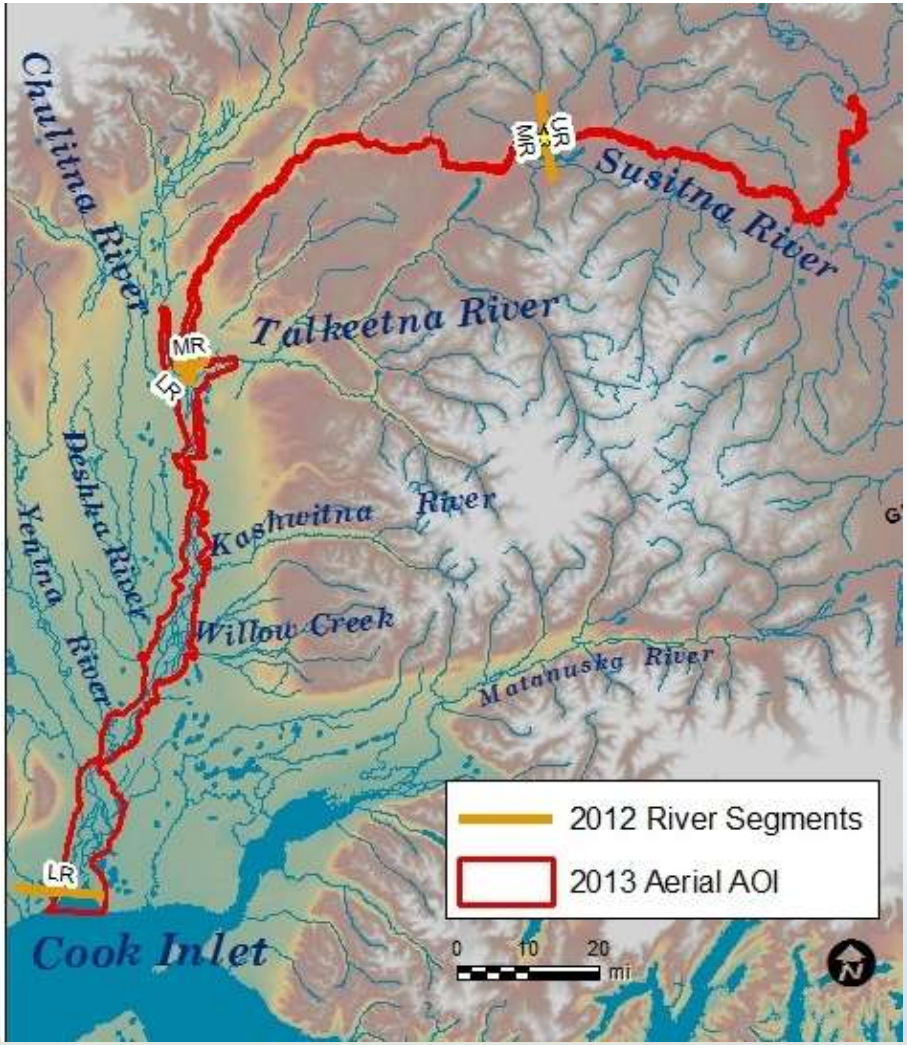
LIDAR VERTICAL ACCURACY TESTS : Initial Results

- The results from the data analysis of MSB 2011 LiDAR data vs. land survey check points collected in 2013 using two different LiDAR processing programs are as follow:

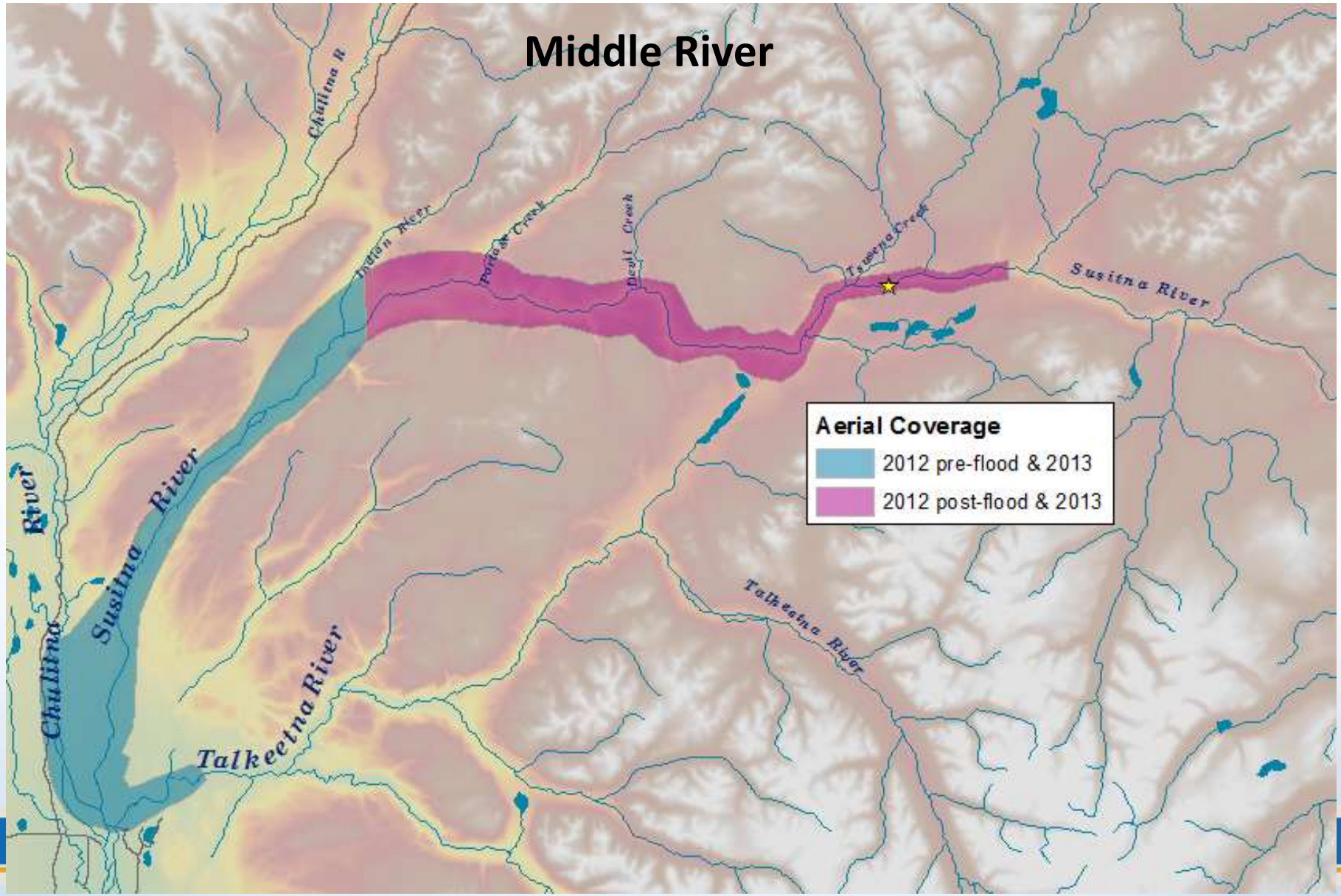
	NPS – POINT SPACING	RMSE (Z)	Fundamental Vertical Accuracy	Consolidated Vertical Accuracy	Supplemental Vertical Accuracy	Equivalent Contour Accuracy
REQUESTED ON MSB 2011	1 meter	≤ 12.5 cm	≤ 24.5 cm	≤ 36.3 cm	≤ 36.3 cm	2 ft.
TERRASCAN	0.59 meter	42.1 cm	82.6 cm	50.4 cm	46.1 cm	5 ft.
LP360	0.57 meter	40.3 cm	79.0 cm	50.6 cm	46.1 cm	5 ft.

Collection of 2013 Aerials

- Collect complete UR, MR and LR
  - 12,500 cfs Gold Creek (MR and UR)
  - 36,600 cfs Sunshine (LR)



Collection of 2013 Aerials
Areas with Pre- and Post 2012 and 2013 Floods



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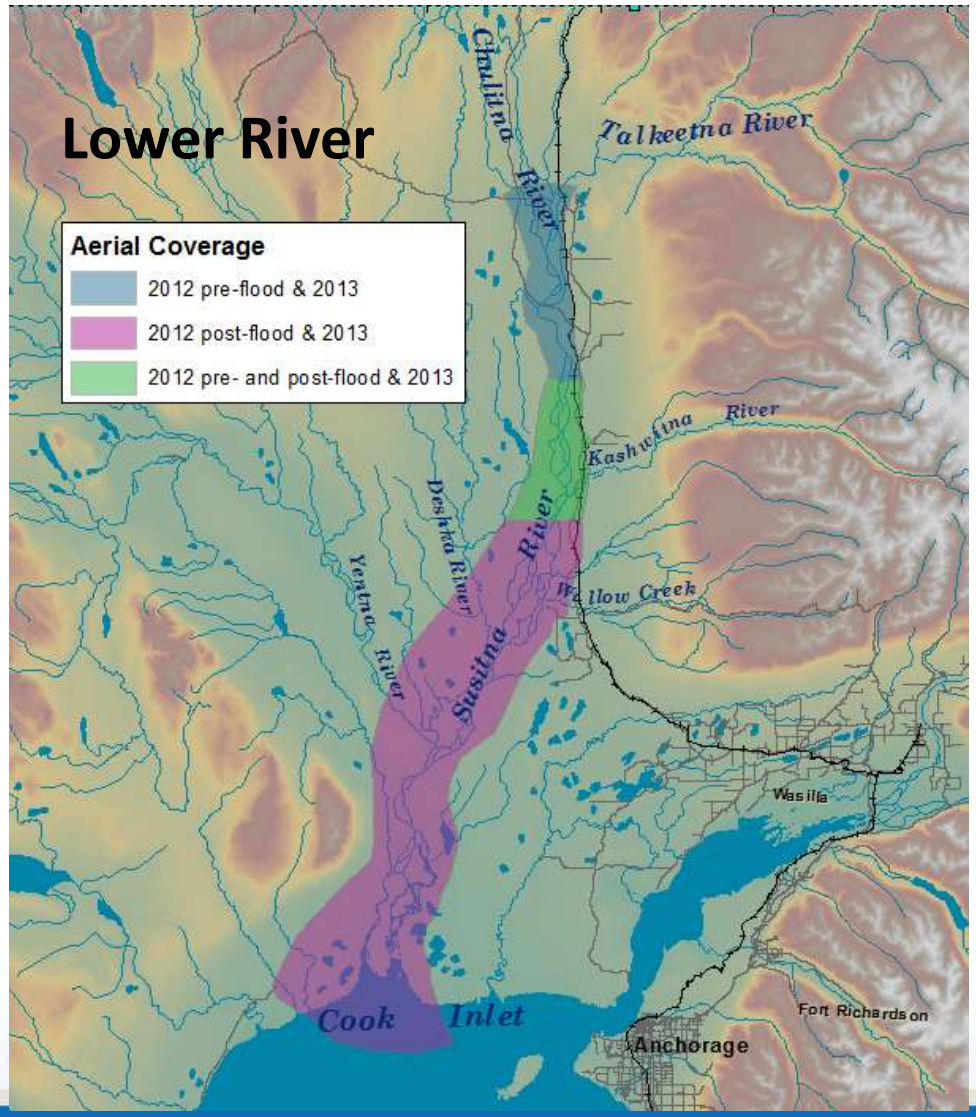
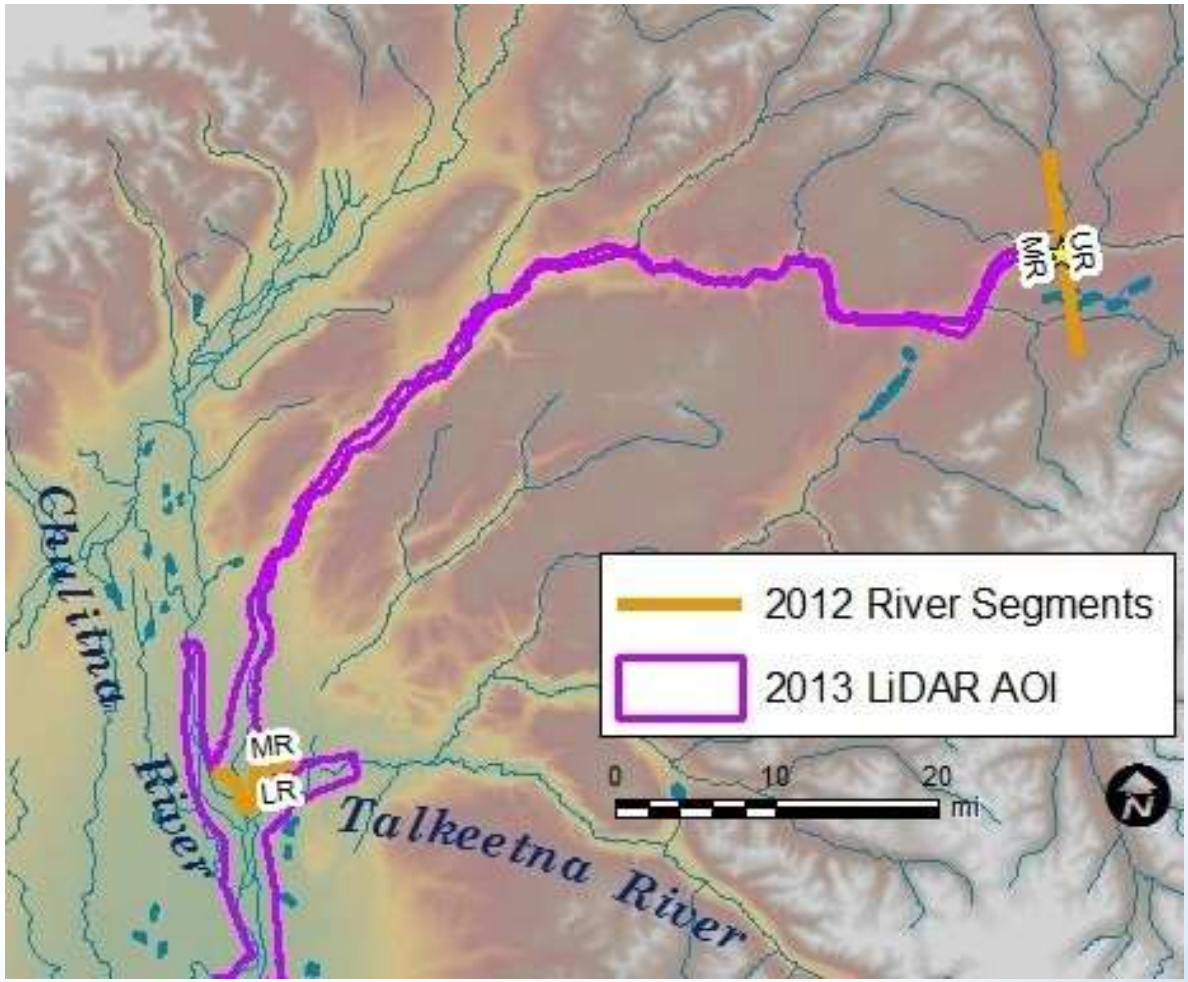


SUSITNA-WATANA HYDRO

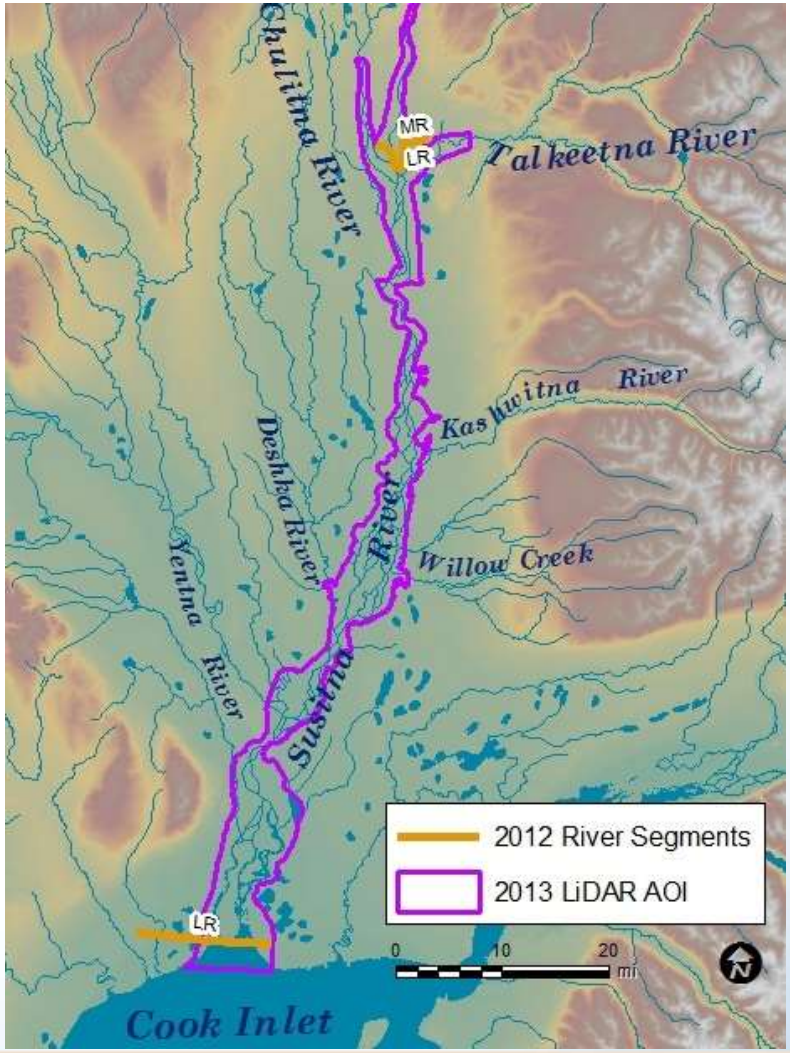
2013 High Density LiDAR Acquisition

- Purpose: Provide above water topo for MR & LR
  - 1-D cross sections
  - Focus Areas



2013 High Density LiDAR Acquisition: Characteristics

- 2011 MSB:
  - 1 pts/m^2 (0.6 actual)
- 2013:
  - 9 pts/m^2
- Target accuracy
  - Bed: 0.5 ft.
  - F.P.: 1 ft.
- Collect at low flow



Use of LiDAR for Macrohabitat Area: Background

- 2012 aerial efforts directed at use of aerials for development of flow vs. macrohabitat area
  - Acquire aerials at 3 MR flows corresponding to 1980s
  - Compare to assess stability of macrohabitat

- If relationships stable from 1980s to present, those developed from 7 flows in 1980s would apply to current conditions

Use of LiDAR for Macrohabitat Area: Results and Difficulties with Aerials

- Could not collect aerials at all three target flows in 2012
  - Flow conditions
  - Weather conditions
- Comparison at 12,500 cfs indicated appreciable differences
  - Some features shifted classification
    - Side channel => side slough
    - Side Slough => side channel
  - Area changes due to geomorphic processes

Use of LiDAR for Macrohabitat Area:
Advantages of LiDAR & Hydraulic Based Approach

- LiDAR less susceptible to flow conditions
  - Single flight required
  - Low flow only
- LiDAR less susceptible to weather
  - Can penetrate thin cloud cover
  - Sun angle not an issue
  - Can be flown at night

Use of LiDAR for Macrohabitat Area:
Advantages of LiDAR & Hydraulic Based Approach (Continued)

- Hydraulics and terrain based approach can directly reflect channel change
- Directly determine area for any flow using hydraulic modeling
- LiDAR provides floodplain topography for other aspects of study:
  - Riparian IFS
  - 1-D cross sections
  - Floodplain areas for 2-D model

Q3 2013 Study Efforts Rescheduled to Q3 2014

Geomorphology Study (RSP 6.5)

Q3 2013 Study Efforts Rescheduled to Q3 2014

- Reservoir tributary delta formation field data collection (RSP 6.5.4.8.2.2)
- Reservoir erosion study field data collection (RSP 6.5.4.8.2.3)
- Geomorphology of stream crossings along transmission lines and access alignments (RSP 6.5.4.10)

Fluvial Geomorphology Modeling Study (RSP 6.6)

Q3 2013 Study Efforts Rescheduled to Q3 2014

1-D model data above PRM 146 (RSP 6.6.4.1.2.9.1)

- Additional X-Sections
- Bed material sampling
- Tributaries sections and bed material

Three Focus Areas above PRM 146 (RSP 6.6.4.1.2.9.2)

- Completed late Q4 2014 or Q1 2015

1-D model extension below PRM 80
(Post RSP – 3/1/13 Focus Area TM)

Upcoming Geomorphology Technical Team Call

- Topics?
  - LiDAR and aerials
  - Q3 field work
  - Specific modeling issues
  - Others
- Date?