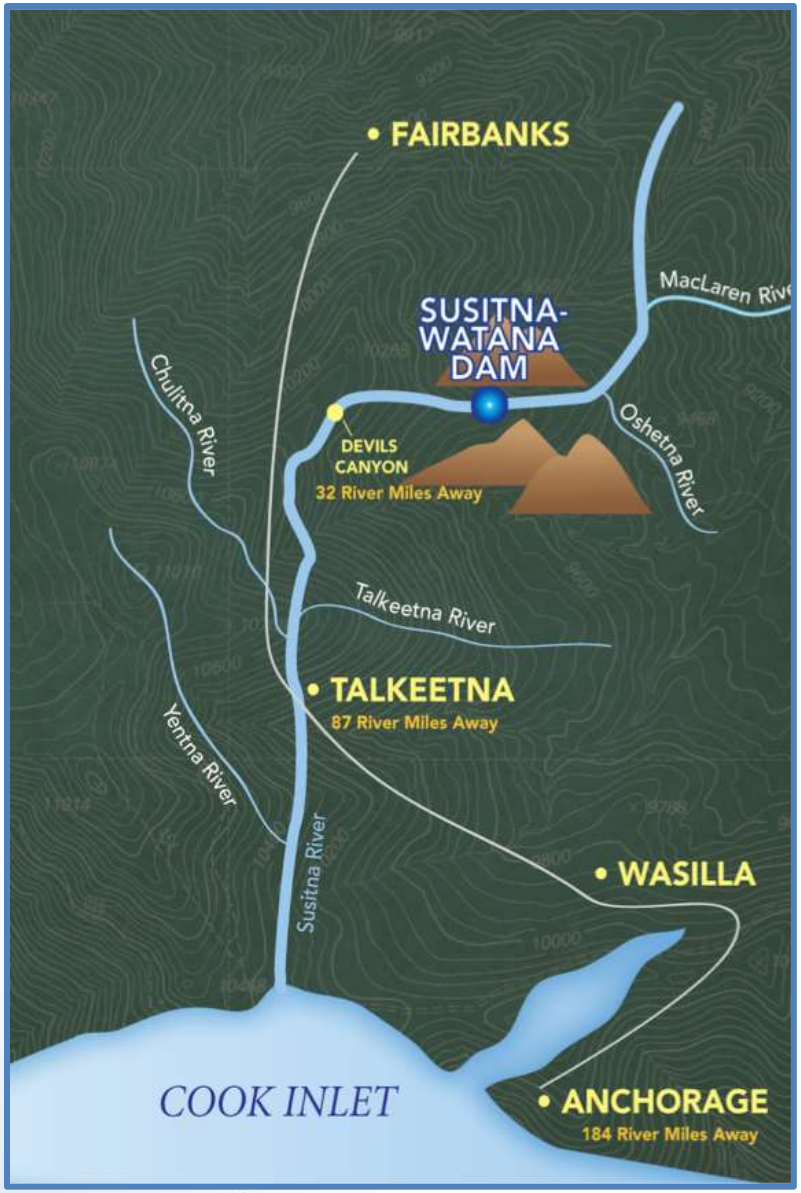

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Technical Team Meeting

Riverine Modeling Proof of Concept

Fluvial Geomorphology Modeling

April 15-17, 2014

Prepared by Tetra Tech

Riverine TT Meeting – Issues Raised

- In addition to velocity and depth, shear stress and Froude number should be included as indicators for spawning suitability.
- In lateral habitats, how will residual flows that are dependent on groundwater be incorporated?
- How will aggradation/degradation, bed mobilization, and geometry changes be incorporated?

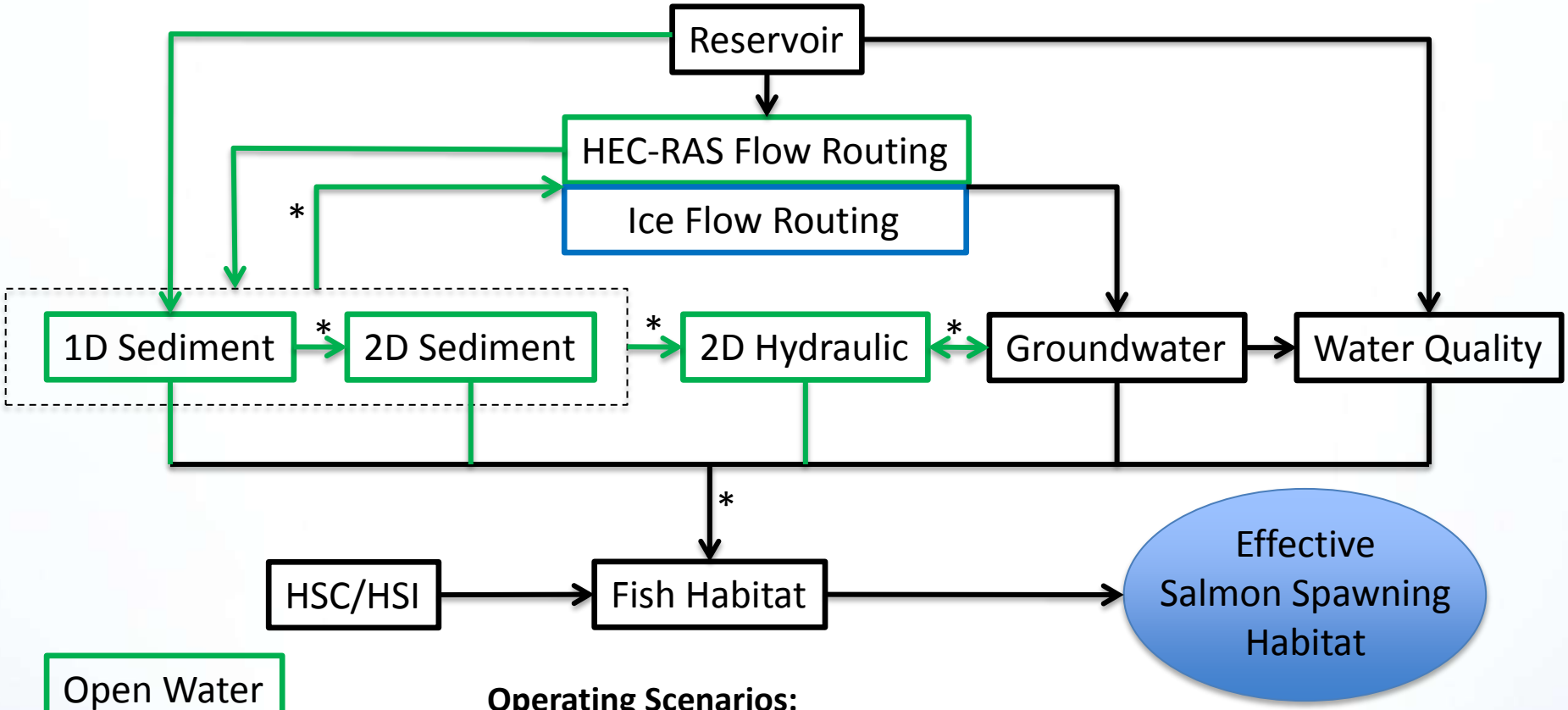
Model Selection Update 2-D

- River-2D limitations
  - Only one sediment input – no tributaries
  - Sediment supply either constant or a percentage of transport capacity
  - Point sources of flow not allowed
- SRH-2D (selected for FGM)
  - None of these limitations identified

Model Selection Update 1-D

- HEC-6T (initially preferred compared to HEC-RAS Version 4.1)
  - Quasi-unsteady (not preferred)
  - Looped network (desired)
- HEC-RAS Version 4.2
  - Fully Dynamic including sediment transport
  - Looped network
  - Superior graphics interface
  - Preferred model depending on performance

FGM Interdependencies Flow Chart



Open Water

Ice Cover

Both or N/A

Operating Scenarios:

- Base Load
- Intermediate Load Following
- Maximum Load Following
- Run of the River

* (Yrs 25 & 50)

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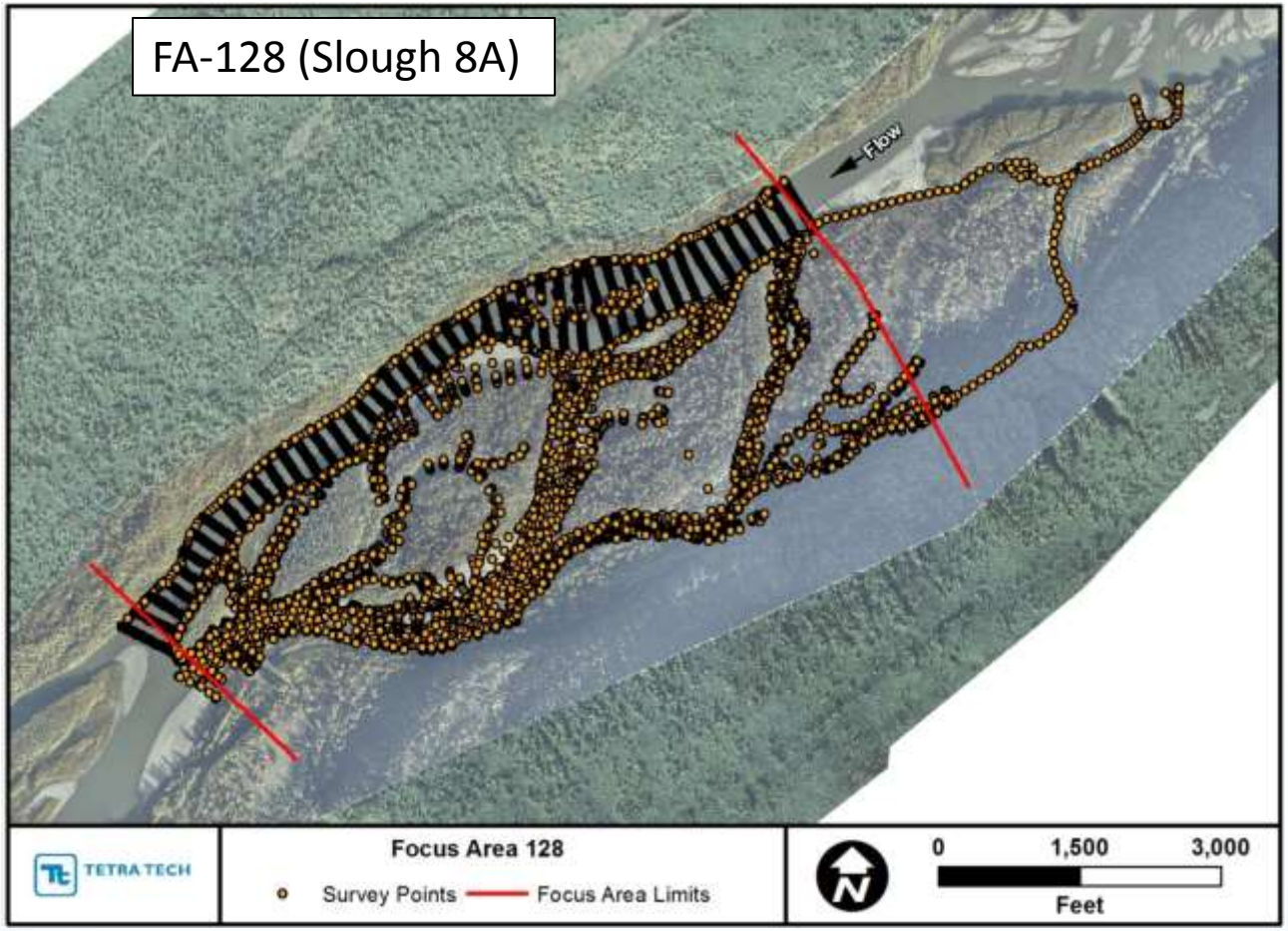
Data for IFS Habitat

Parameter	Parameter Definition
Point_ID	Element ID
Area_ft^2	Area of element (square ft)
Centroid_X_ft	Easting coordinate of element centroid (ft)
Centroid_ Y_ft	Northing coordinate of element centroid (ft)
Bed_Elev_ft	Elevation of element centroid (ft)
Water_Elev_ft	Water surface elevation (ft)
Water_Depth_ft	Water depth (ft)
Vel_X_ft_p_s	Velocity compenent in the X-direction (ft/s)
Vel_Y_ft_p_s	Velocity compenent in the Y-direction (ft/s)
Vel_Mag_ft_p_s	Velocity magnitude (ft/s)
Froude	Froude number
Strs_lb_p_ft2	Shear Stress (lb/ft^2) (Total shear stress from model Manning n (includes veg.)
Dcrit_mm	Particle size of incipient motion (mm) - Shields Parameter = 0.045
Bed_Strs_lb_p_ft2	Shear Stress (lb/ft^2) (Shear excluding vegetation – Manning n = 0.03)
Dcrit_mm	Particle size of incipient motion (mm) - Shields Parameter = 0.045 (n = 0.03)

Model Development
Survey and Bathymetric Data



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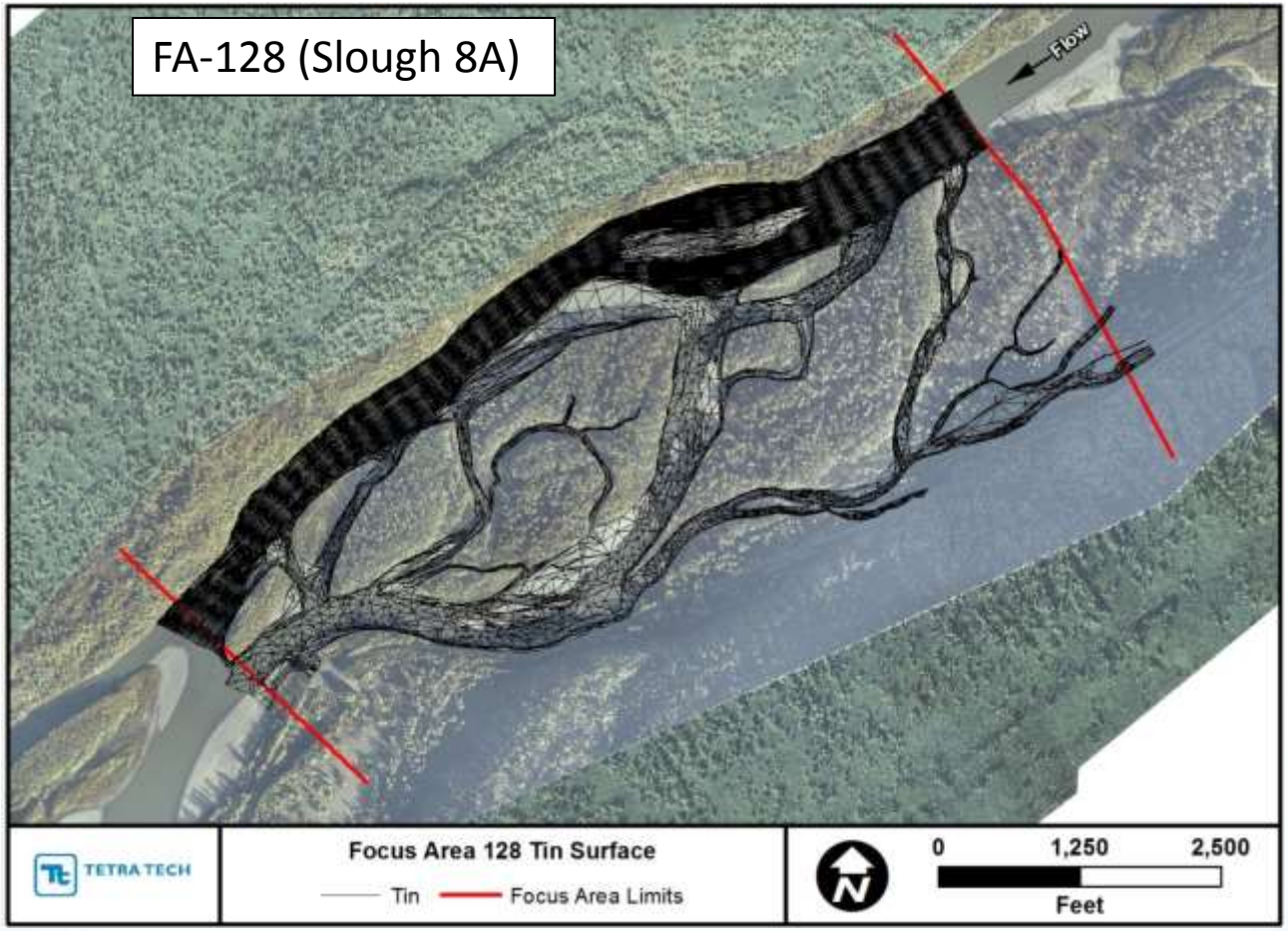
Model Development
Survey and Bathymetric Data - TIN



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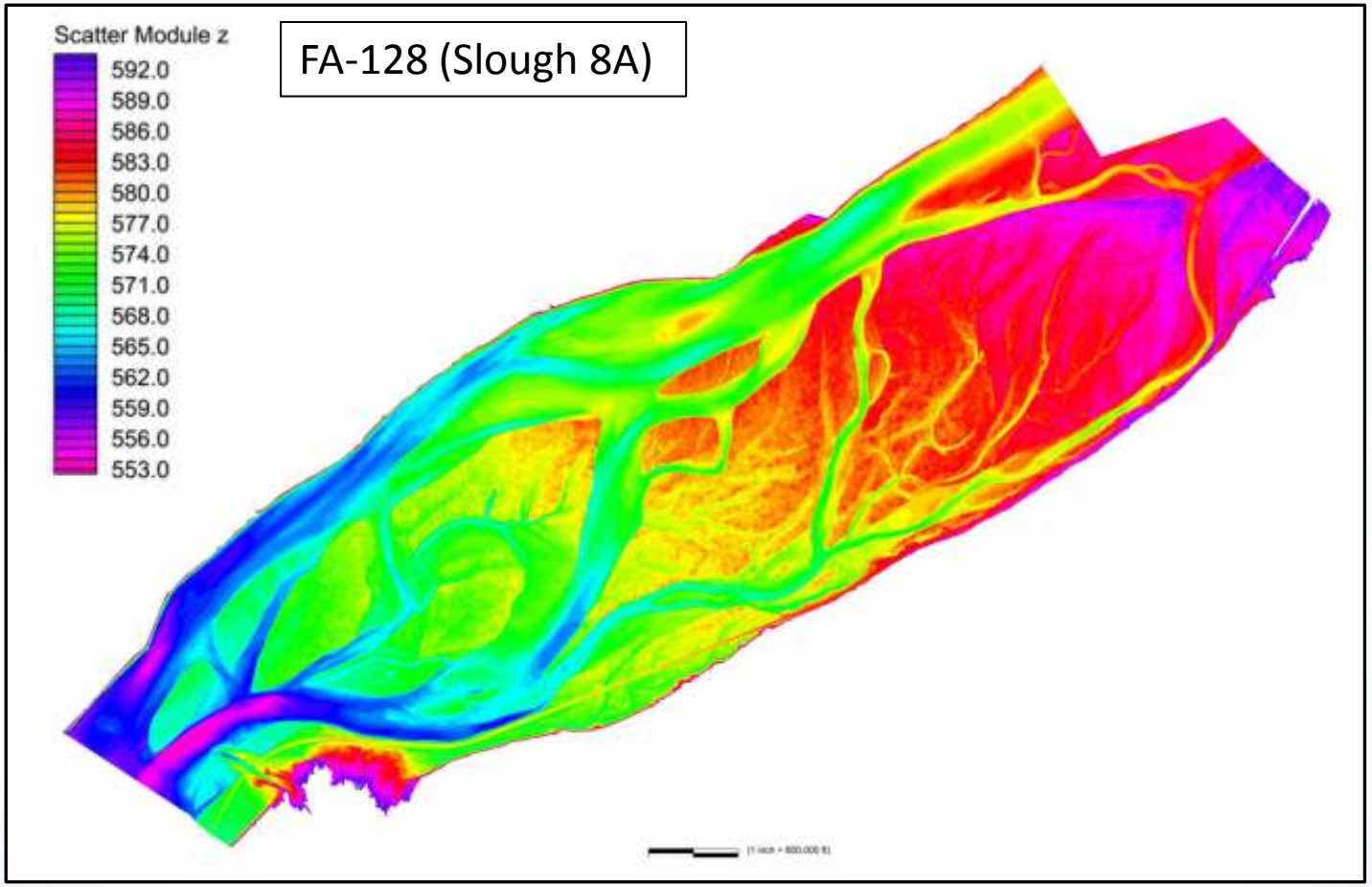
Model Development
TIN contour map (includes LiDAR)



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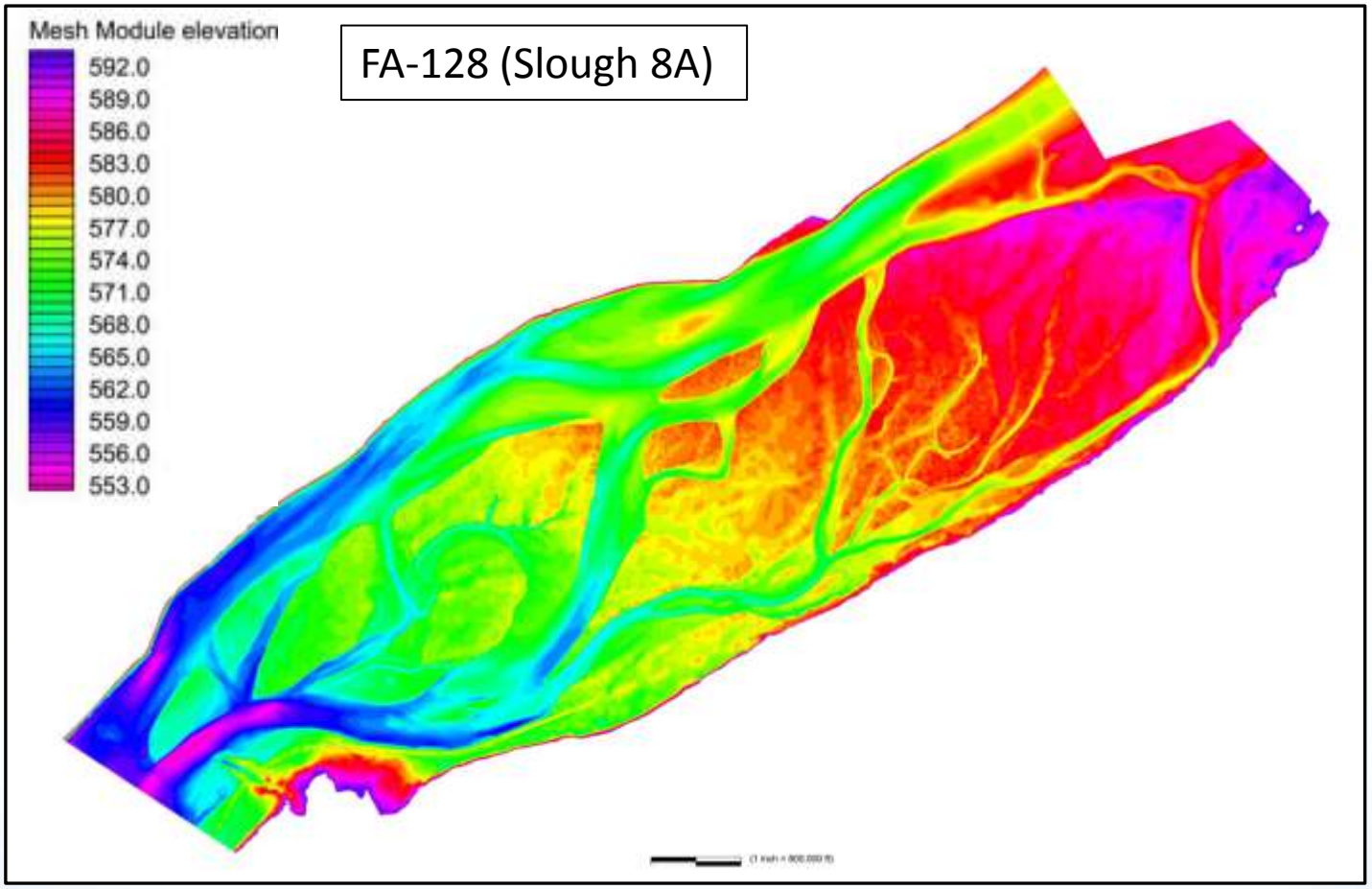
Model Development
Hydraulic Model contour map



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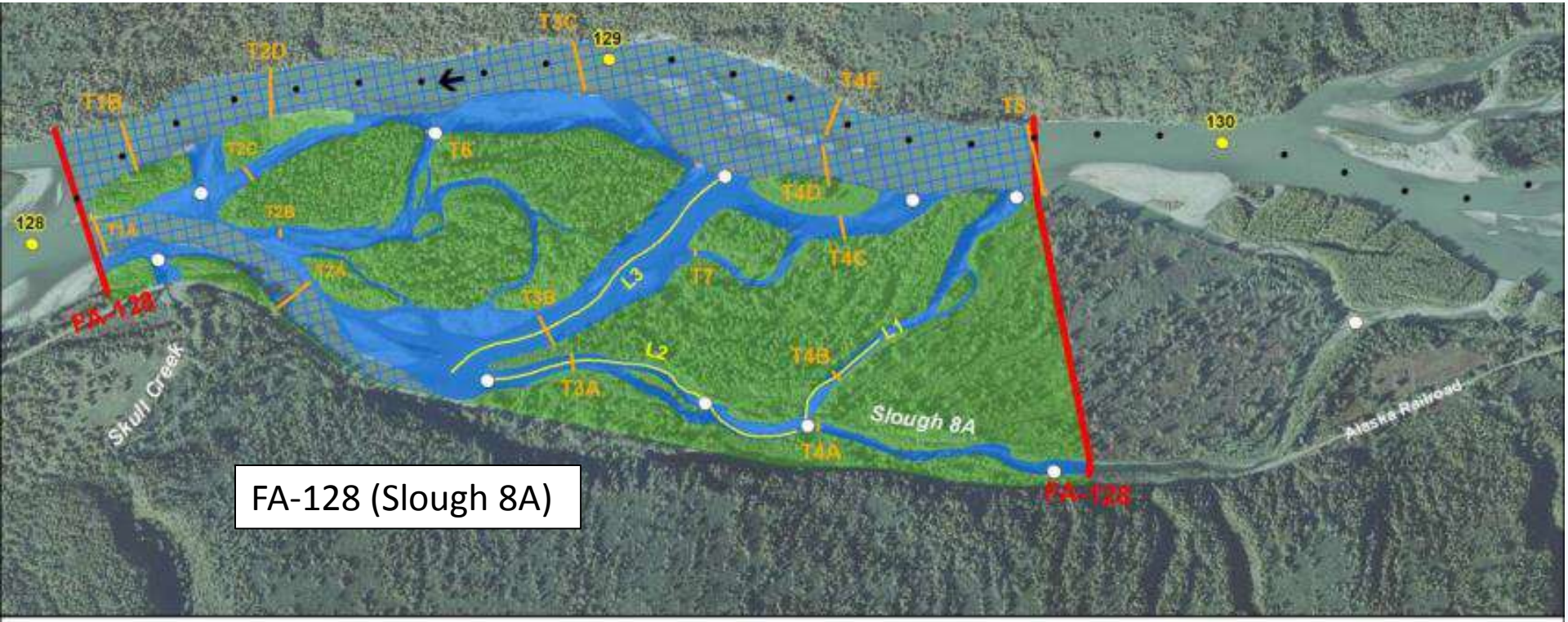
Model Development
Coarse and Fine Mesh Criteria



FA-128 (Slough 8A)

Legend

- 2-D Fine Mesh
- 2-D Coarse Mesh
- 2-D Coarse Mesh (Upland)
- 2-D Model Calibration Transect
- Project River Mile
- Channel Inlet/Outlet Measurement

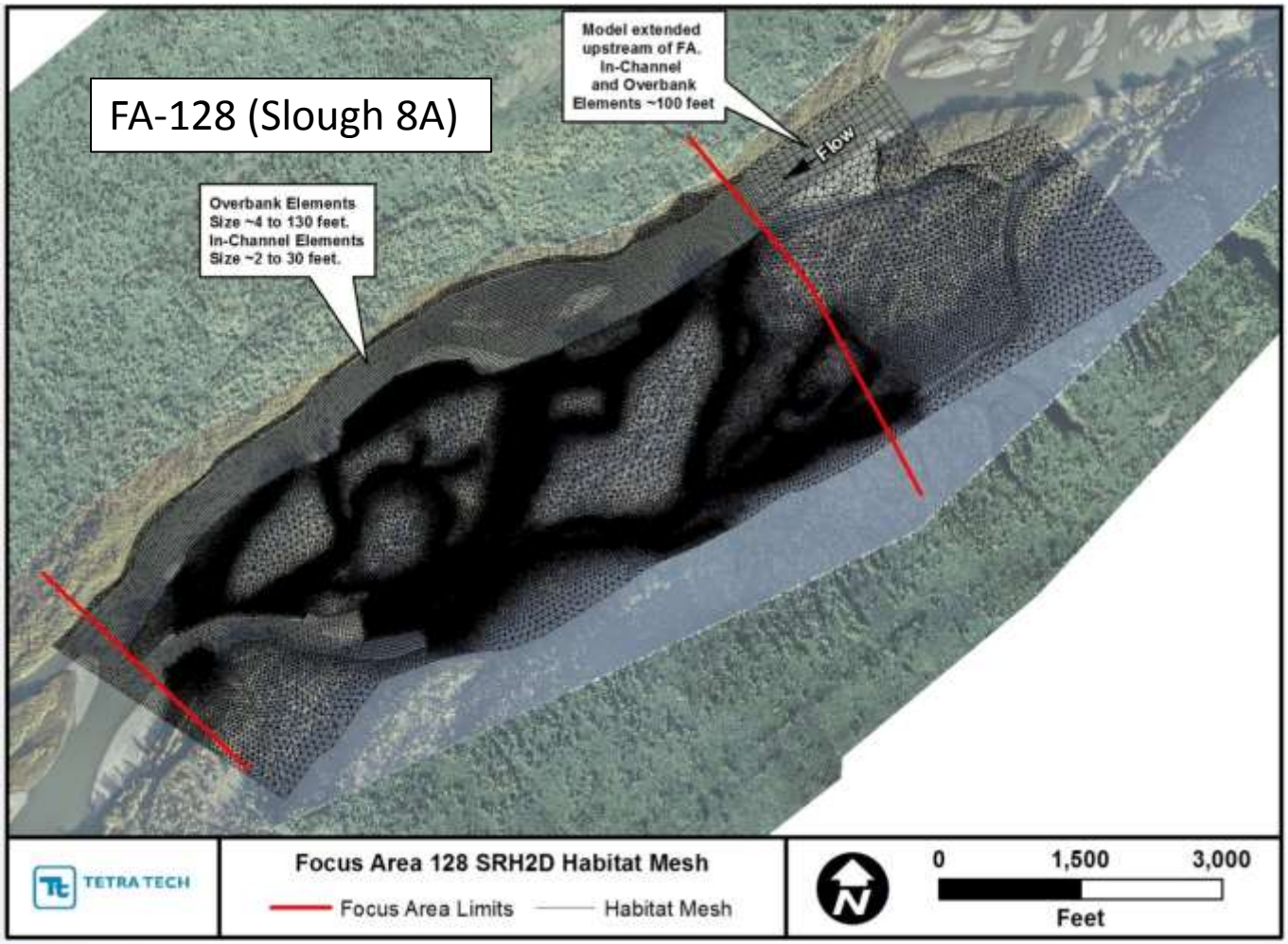
Orthophoto Source: 2012 Tetra Tech, Inc. Data Sources: See Map References

ALASKA ENERGY AUTHORITY

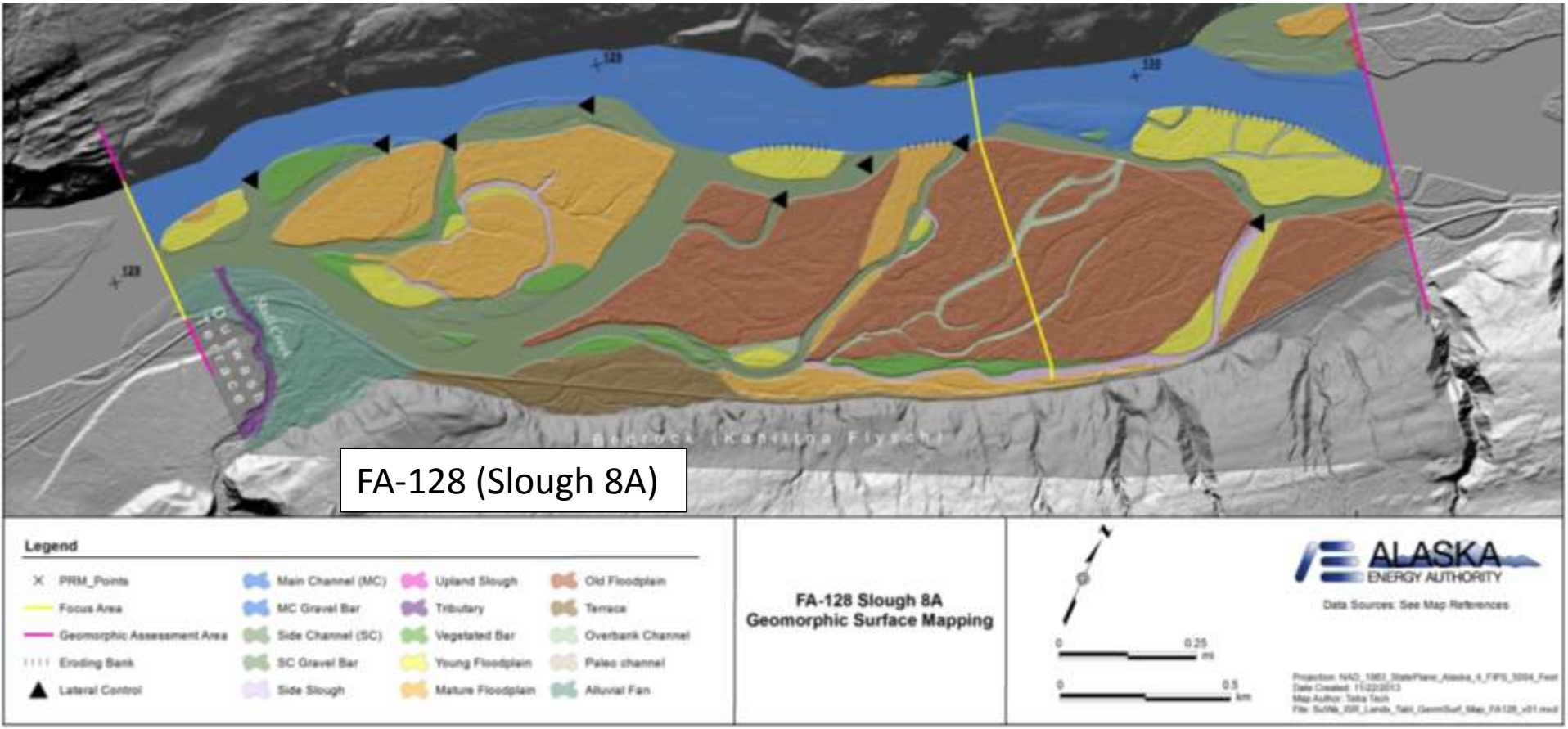
0 1,000 Feet

Projection: AK SP Zone 4 NAD 1983
Date Created: 12/16/2013
Map Author: R2 - Joella Zablotney
File: Map_ISR_IFS_2DModel.mxd

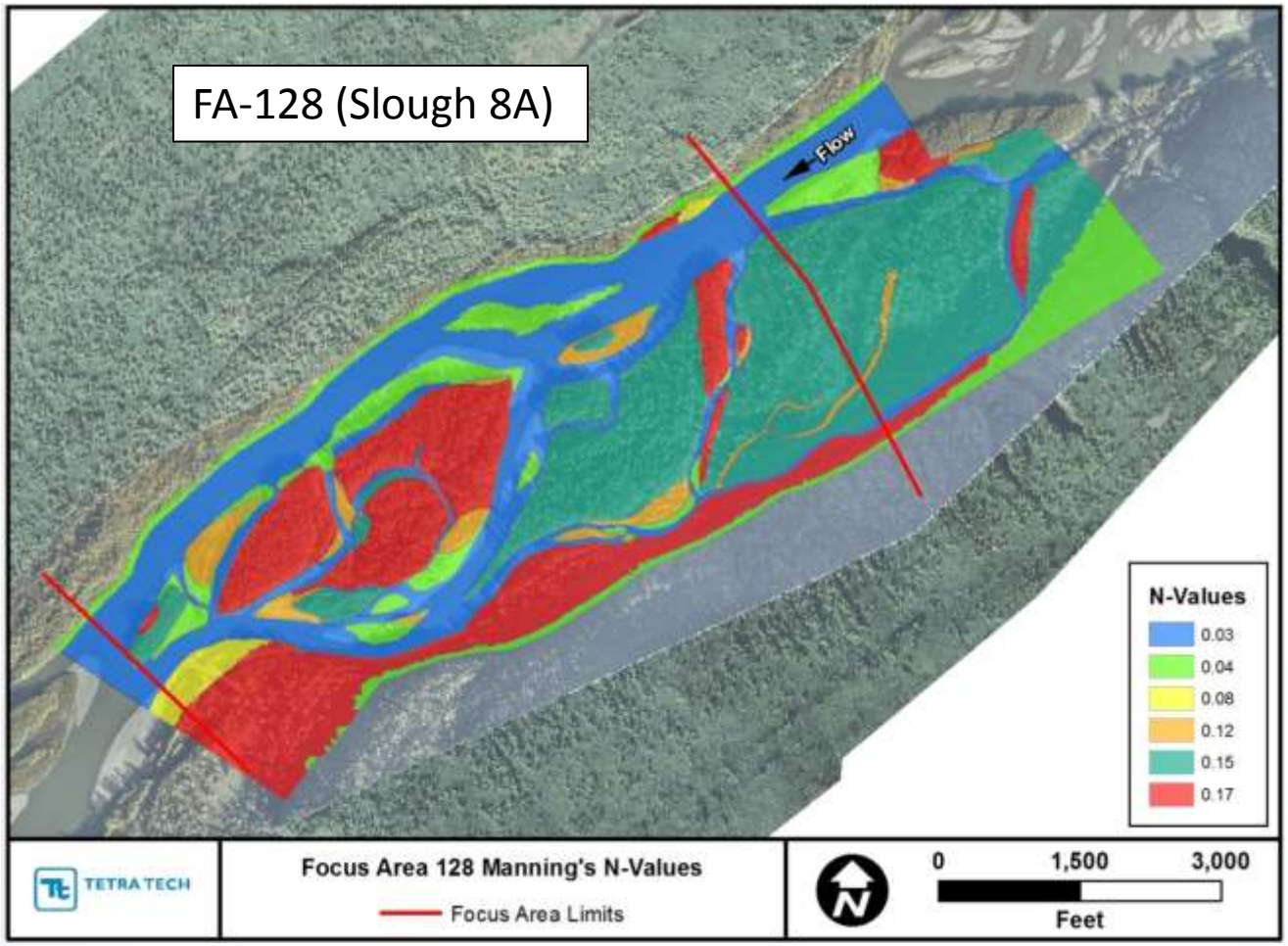
Model Development
Mesh Resolution



Model Development
Geomorphic Mapping



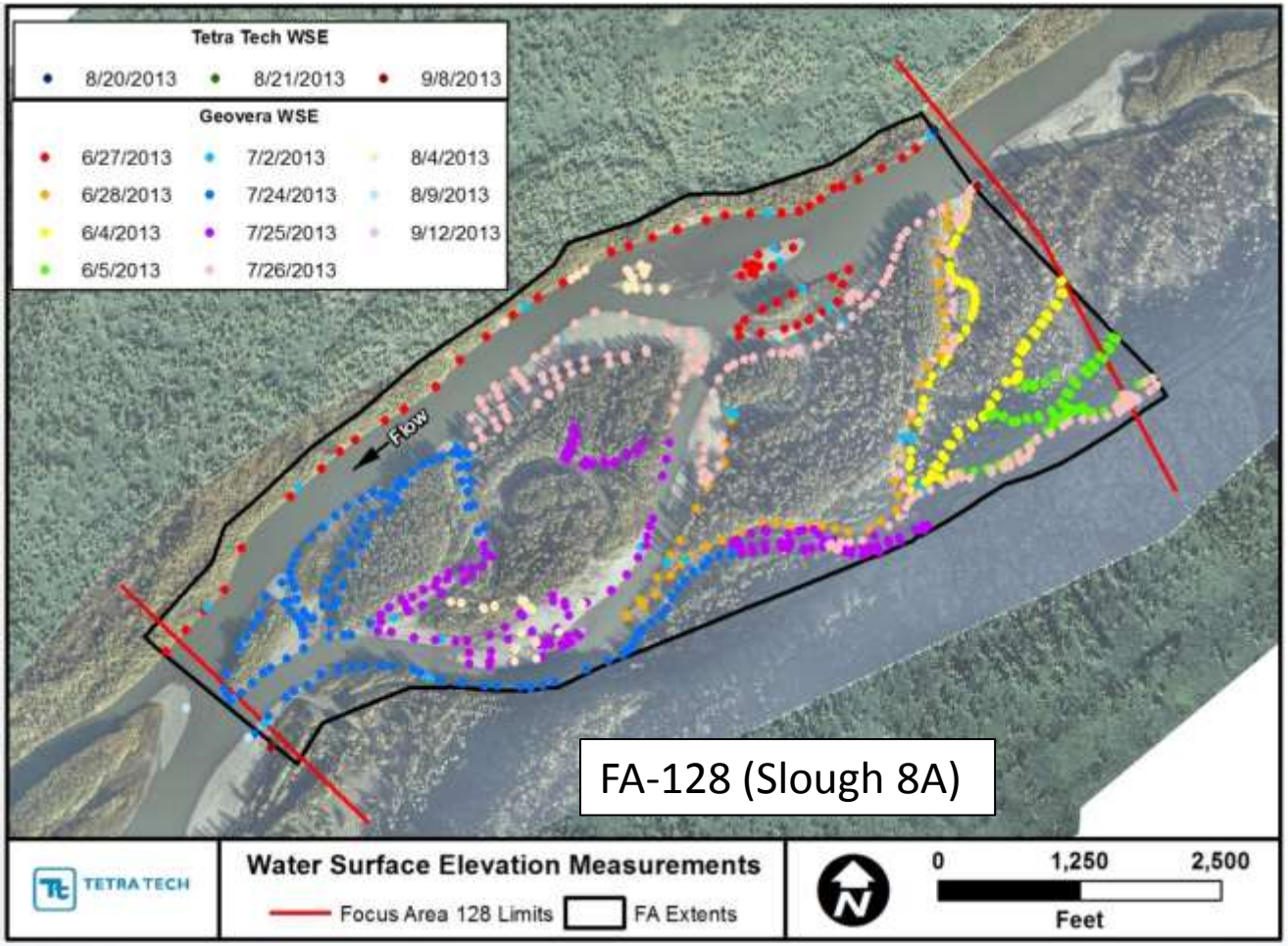
Model Development
Roughness (Manning's n)



Model Calibration

- Water Surface Elevation Data
  - During ADCP data collection
  - During bathymetric survey
  - Additional points by field crews
- ADCP Data
  - Velocity
  - Discharge distribution in main channel and lateral features

Model Calibration
Water Surface Elevations



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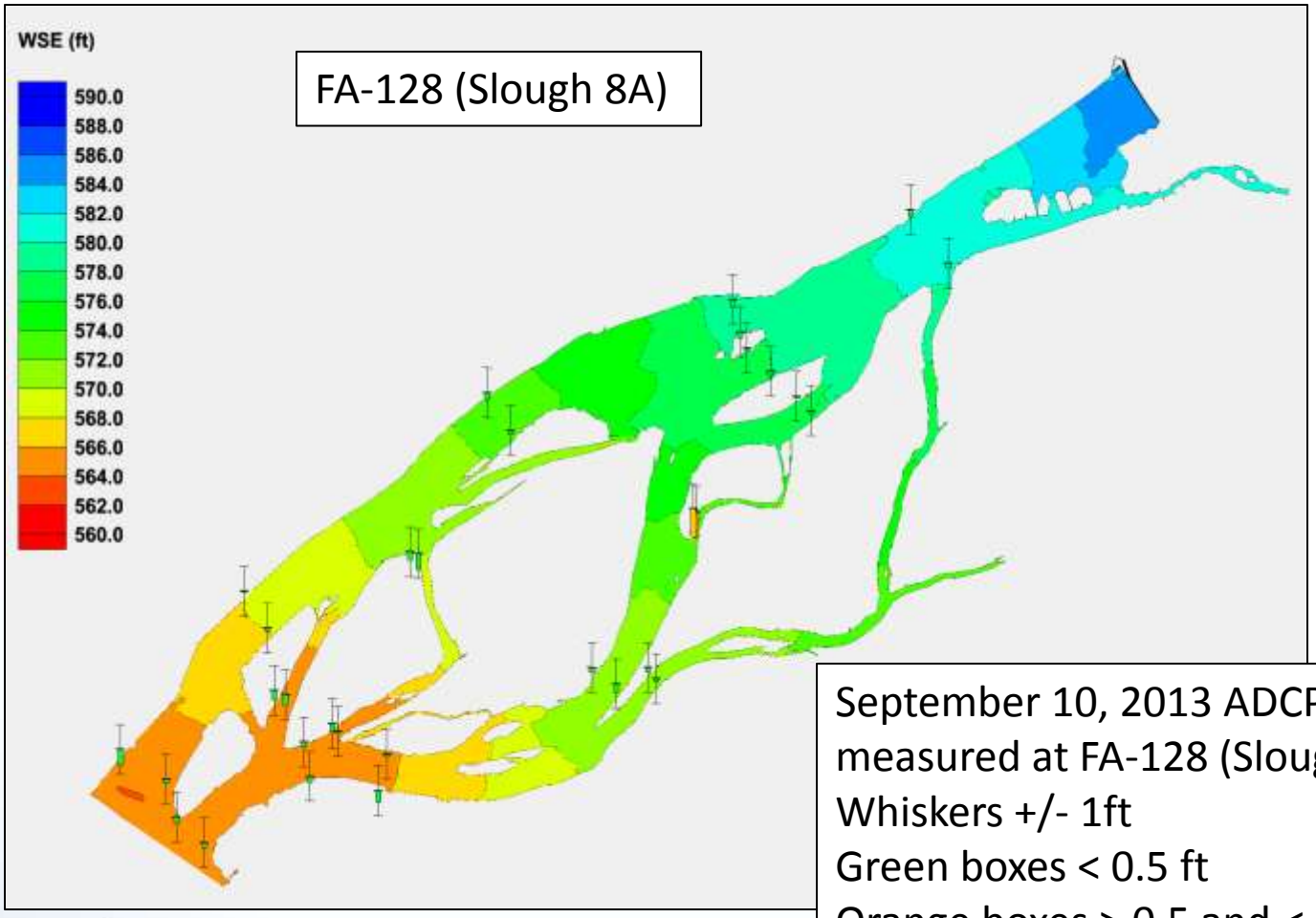
Model Calibration
Water Surface 9/10/13



September 10, 2013 ADCP 26,124 cfs measured at FA-128 (Slough 8A)
Whiskers +/- 1ft
Green boxes < 0.5 ft
Orange boxes > 0.5 and < 1.0 ft

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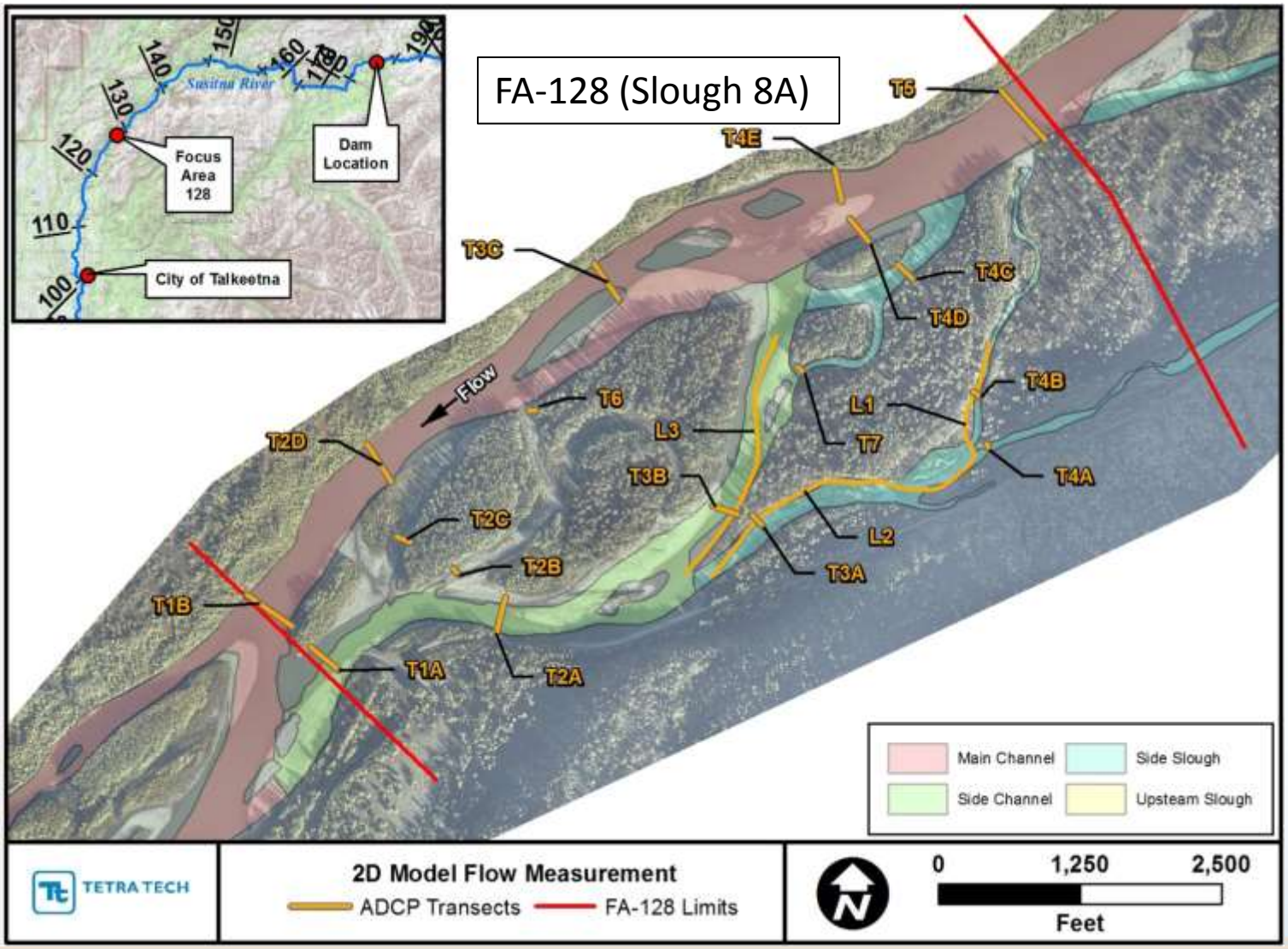
Model Calibration
Water Surface Summary

Model Run	Discharge (cfs)	No. Measurements	Ave. Diff (ft)
4-Jun-13	54,203	63	0.66
2-Jul-13[A]	24,705	32	0.11
24-Jul-13	20,132	129	-0.01
4-Aug-13	20,069	33	0.11
21-Aug-13	36,636	2	-0.07
8-Sep-13	32,200	2	-0.08
10-Sep-13[A]	26,124	32	-0.30

[A]ADCP Measurements Collected at FA-128 (Slough 8A)
Other Discharges estimated from Gold Creek Gage (PRM 140.1)

Model Calibration
ADCP Velocity and Discharge Locations



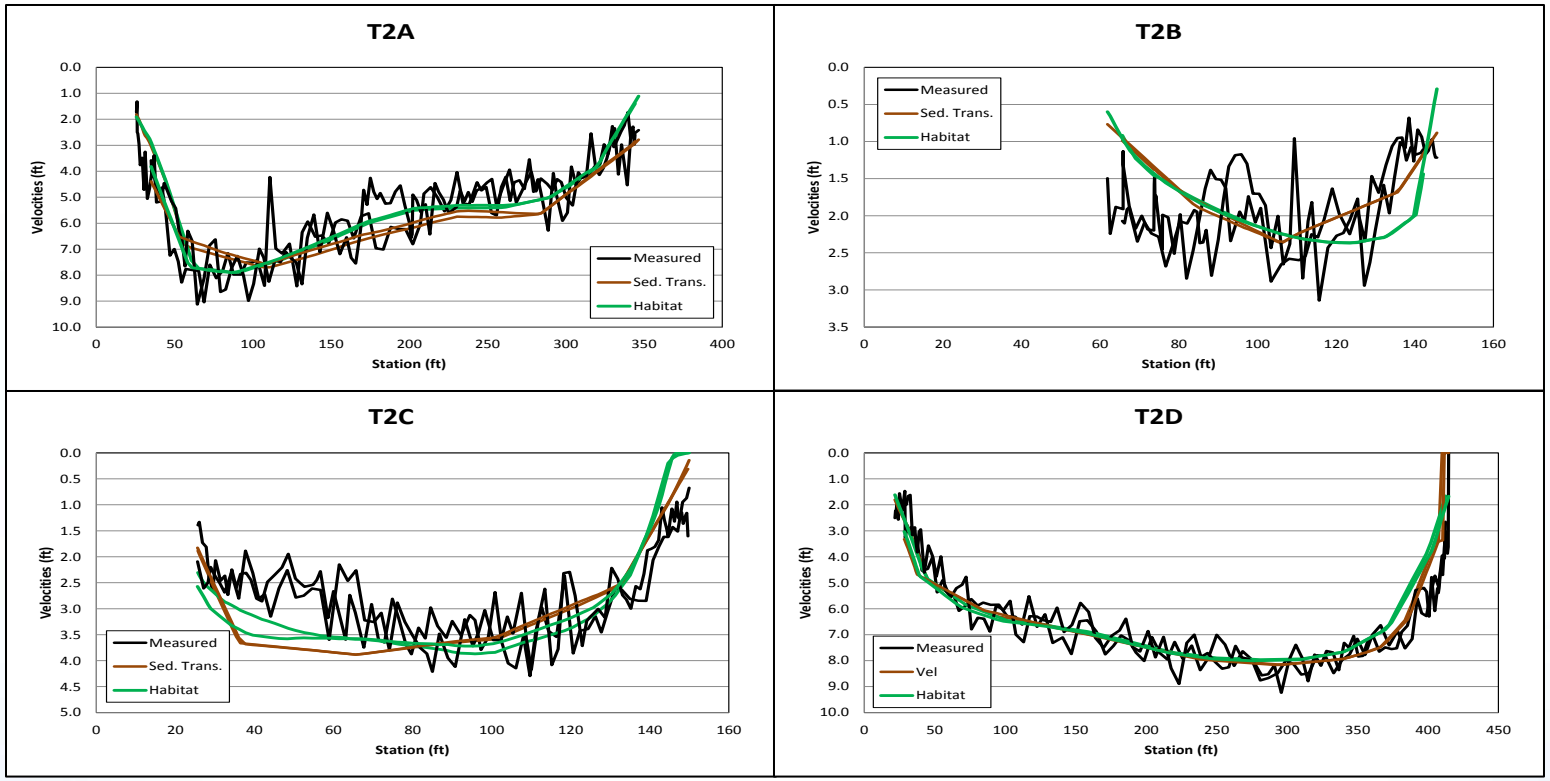
Model Calibration
ADCP Discharge at FA-128 (Slough 8A)

Date/Time	Transect	Flow (cfs)					Total Flow
		Far left	Left	Middle	Right	Far right	cfs
7/2/13 13:14	T1		7,520		17,197		24,717
7/2/13 12:46	T2	236	6,204	766	17,710		24,916
7/2/13 12:12	T3		379	5,843	18,413		24,635
7/2/13 11:26	T4	9.10	374	2,629	12,818	8,745	24,575
7/2/13 10:58	T5			24,538			24,538
7/2/13 12:24	T6			231			24,651
7/2/13 15:36	T7			2.95			24,905
						Average	24,705
9/10/13 14:03	T1		8,547		17,551		26,098
9/10/13 13:40	T2		6,960	1,134	18,019		26,113
9/10/13 13:13	T3		473	6,331	19,328		26,132
9/10/13 12:20	T4		473	2,907	13,659	9,127	26,167
9/10/13 11:54	T5			26,184			26,184
9/10/13 13:26	T6			250			26,123
9/10/13 15:10	T7			3.68			26,053
Note: For discharge measurement locations refer to FA128 (Slough 8A) map						Average	26,124

Model Calibration
ADCP Discharge data vs. Model

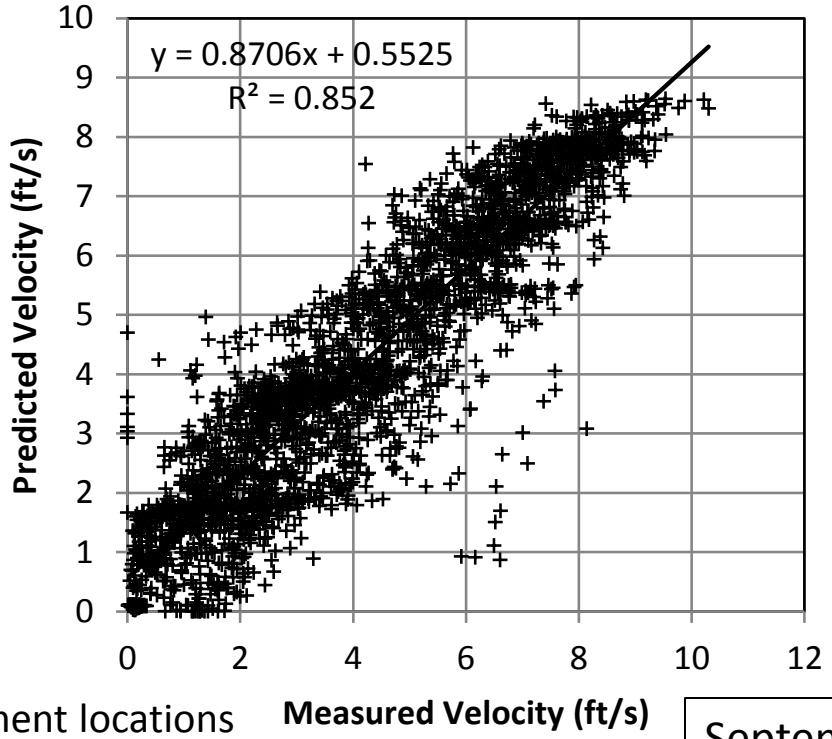
Transect	Measured		Hydraulic Model			
	Meas. (cfs)	% of Total Flow	Pred. (cfs)	% of Total Flow	Diff. (cfs)	% Diff
T1A	8,547	33%	8,595	33%	48	1%
T1B	17,551	67%	17,528	67%	-23	0%
T2A	6,960	27%	6,766	26%	-194	-3%
T2B	250[A]	0.96%	336	1.28%	86	34%
T2C	1,134	4.3%	925	3.5%	-209	-18%
T2D	18,019	69%	18,096	69%	77	0%
T3A	473	1.8%	619	2.4%	146	31%
T3B	6,331	24%	6,155	24%	-176	-3%
T3C	19,328	74%	19,325	74%	-3	0%
T4A	No Meas.		0			
T4B	473	1.8%	619	2.4%	146	31%
T4C	2,907	11.1%	3,367	12.9%	460	16%
T4D	13,659	52%	13,015	50%	-644	-5%
T4E	9,127	35%	9,123	35%	-4	0%
T5	26,184	100%	26,124	100%	-60	0%
T6	250	1.0%	328	1.3%	78	31%
T7	3.7	0.014%	10.7	0.041%	7.0	191%
Note: For discharge measurement locations refer to FA-128 (Slough 8A) map						

Model Calibration
ADCP Velocity data vs. Model



Note: For discharge measurement locations refer to FA128 (Slough 8A) map

Model Calibration
ADCP Velocity data vs. Model



Note: All velocity measurement locations shown on FA-128 (Slough 8A) map

September 10, 2013 at 26,124 cfs measured at FA-128 (Slough 8A)
Note: ADCP data include brief turbulent fluctuations

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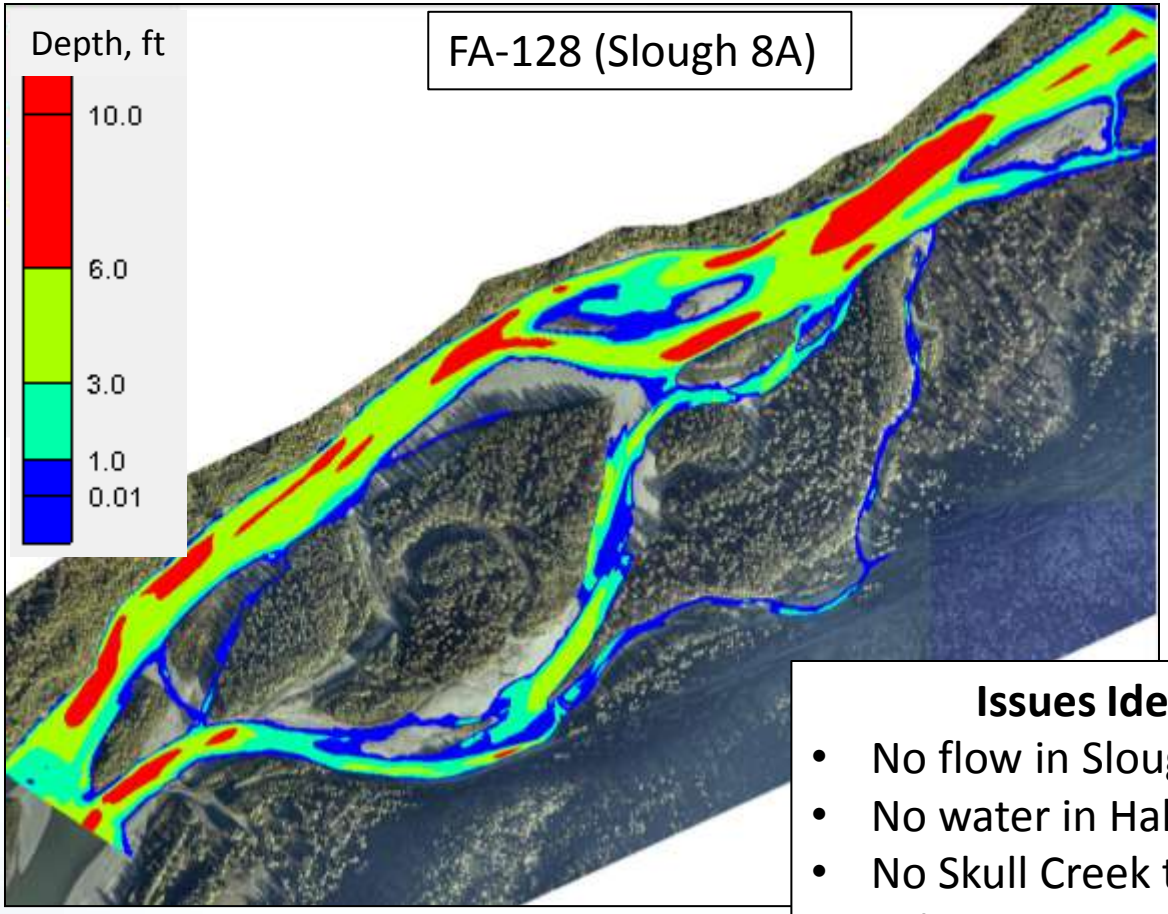
Hydraulic Model Results

- Simulation discharges at FA-128 (Slough 8A): 2K, 4K, 8K, 12K, 16K, 22K, 30K, and 50K cfs (50K cfs approximate 2-year flow)
- Primary results variables
  - Velocity and depth at each element
- Secondary results variables
  - Shear stress, critical bed material size for bed mobilization, and Froude number

Hydraulic Model Results
12K cfs Initial Run – Water Depth



Issues Identified

- No flow in Slough 8A
- No water in Half Moon Slough
- No Skull Creek tributary flow
- Other non-wetted areas

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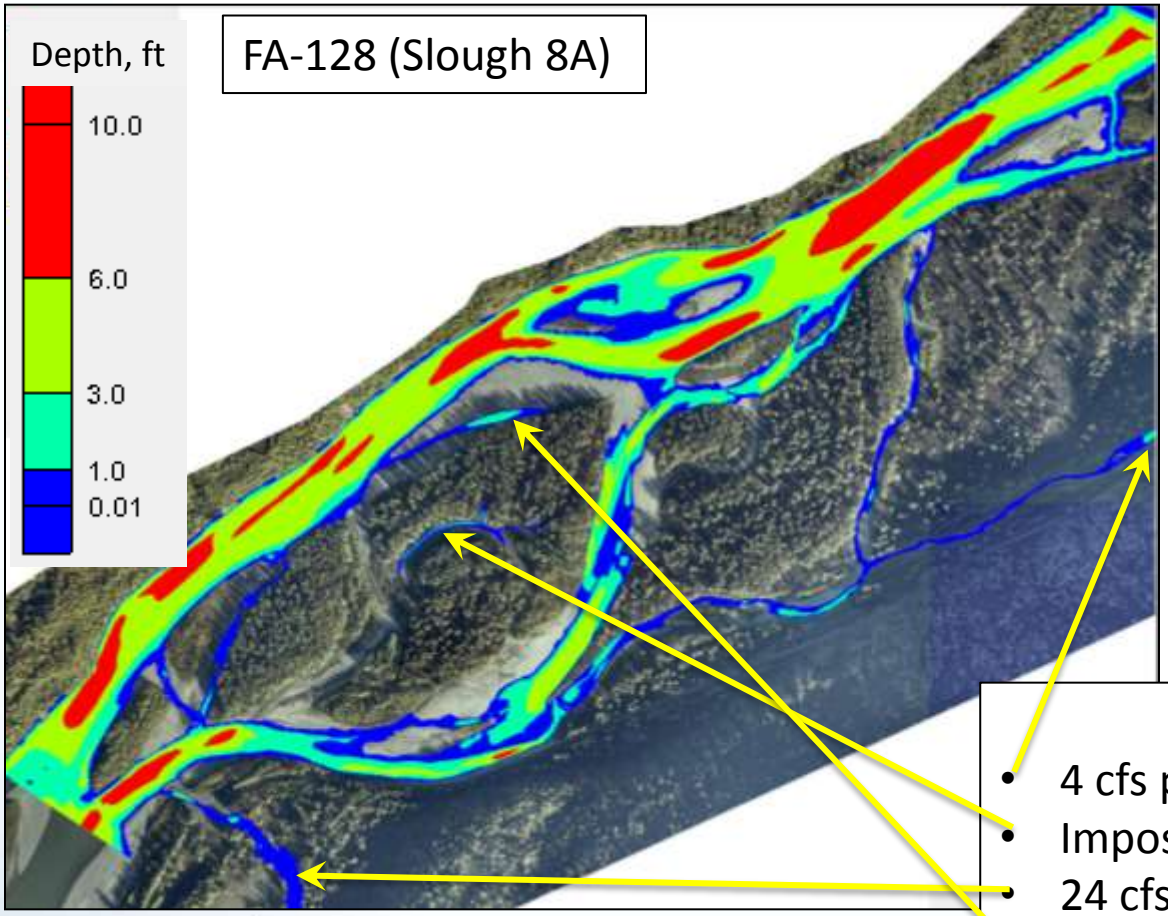
Hydraulic Model Results: FA-128 (Slough 8A) Issue Identification

- Slough 8A has groundwater source until breached from upstream
- Half Moon Slough and other interior locations have persistent subsurface sources
- Side channels/sloughs have hyporheic flow exchange between surface and shallow ground water until breaching occurs

Hydraulic Model Results: FA-128 (Slough 8A) Preliminary Issue Resolution

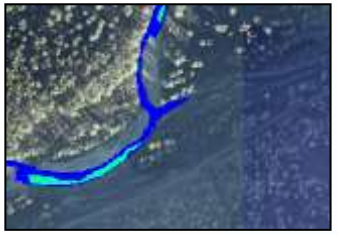
- Slough 8A and Half Moon Slough have observed flow and water surface data
- Need to estimate other hyporheic exchange flows including sources and sinks
- Include sources and sinks into SRH-2D models

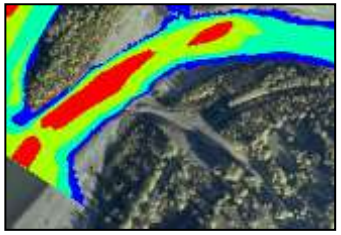
Hydraulic Model Results
12K cfs Revised Run – Water Depth

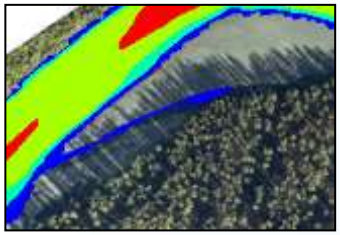


Initial Run


Half Moon Slough


Slough 8a


Skull Creek


Backwater

Preliminary Adjustments

- 4 cfs point source in Slough 8A
- Imposed 568.7 WSEL Half Moon Slough
- 24 cfs tributary flow in Skull Creek
- Deeper backwater – longer simulation

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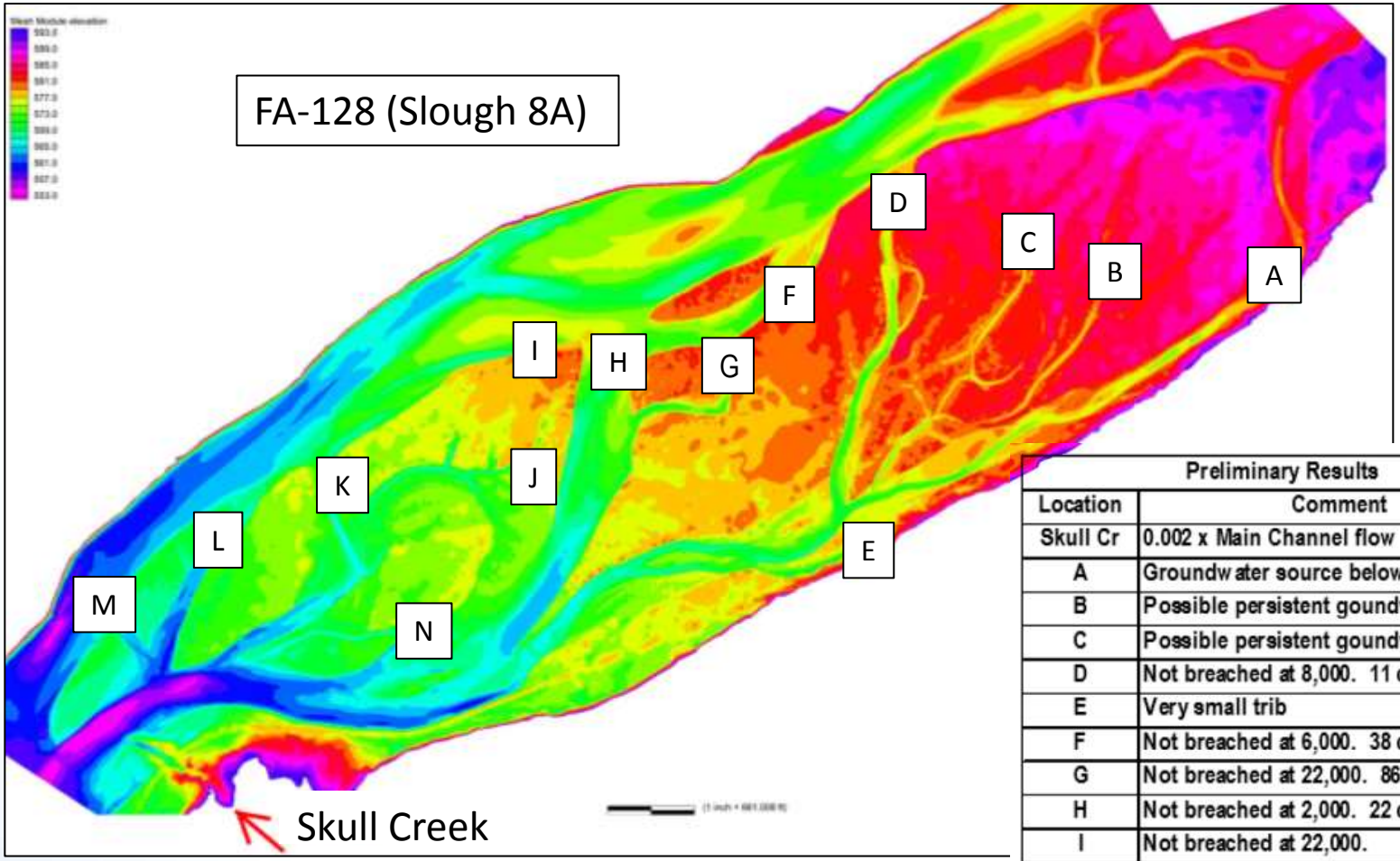
Surface/Ground Water Interactions



Preliminary Results	
Location	Comment
Skull Cr	0.002 x Main Channel flow
A	Groundwater source below ~30,000 cfs
B	Possible persistent goundwater source
C	Possible persistent goundwater source
D	Not breached at 8,000. 11 cfs at 12,000
E	Very small trib
F	Not breached at 6,000. 38 cfs at 8,000
G	Not breached at 22,000. 86 cfs at 30,000
H	Not breached at 2,000. 22 cfs at 4,000
I	Not breached at 22,000.
J	Halfmoon bay, muliple sources.
K	Not breached at 12,000. 8 cfs at 16,000
L	Not breached at 8,000. 2 cfs at 12,000
M	Not breached at 8,000. 46 cfs at 12,000
N	Not breached at 22,000. 24 cfs at 30,000

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Surface/Ground Water Interactions

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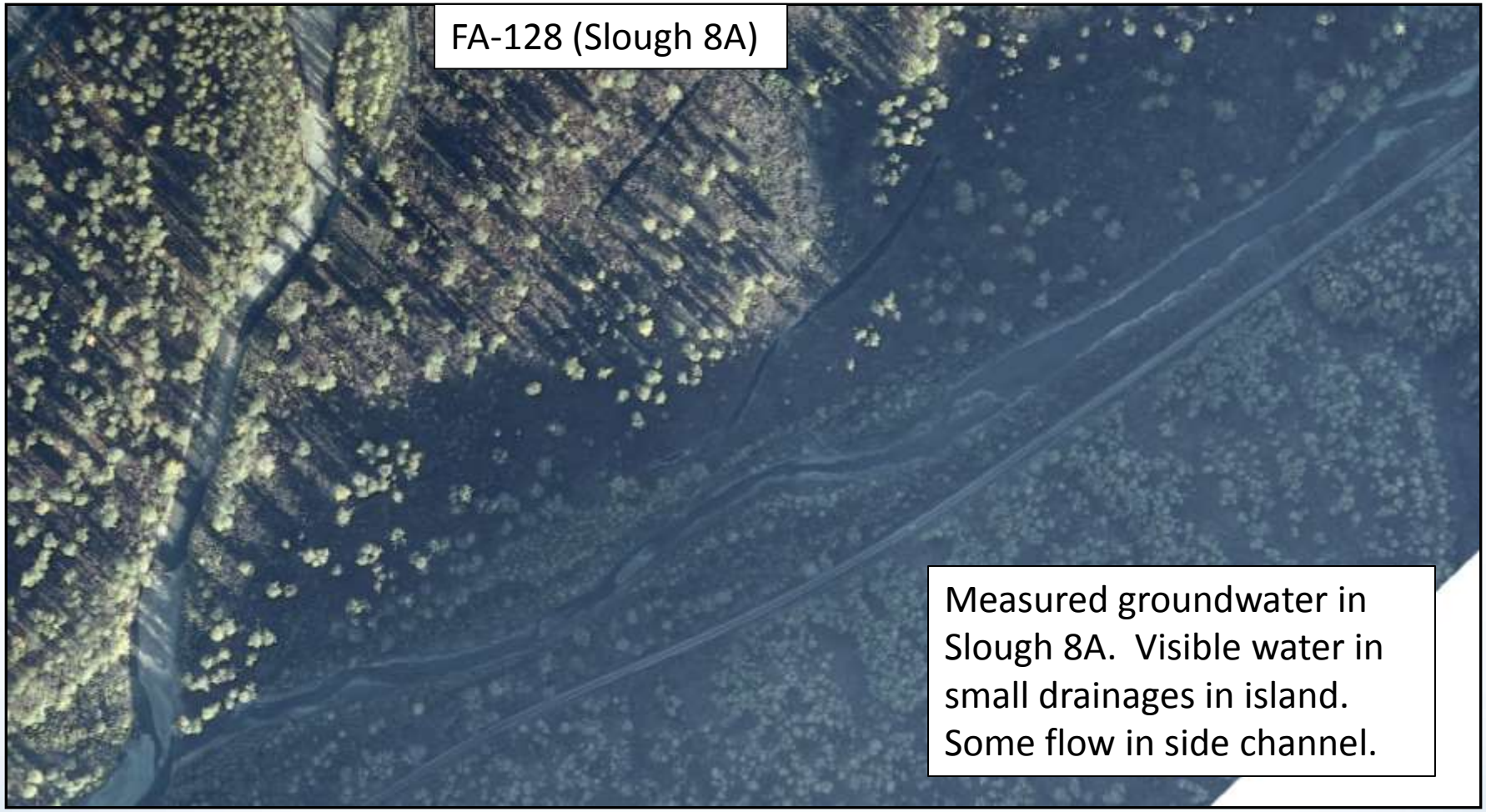
Surface/Ground Water Interactions



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Surface/Ground Water Interactions

FA-128 (Slough 8A)

11,300 cfs estimated from Gold Creek gage

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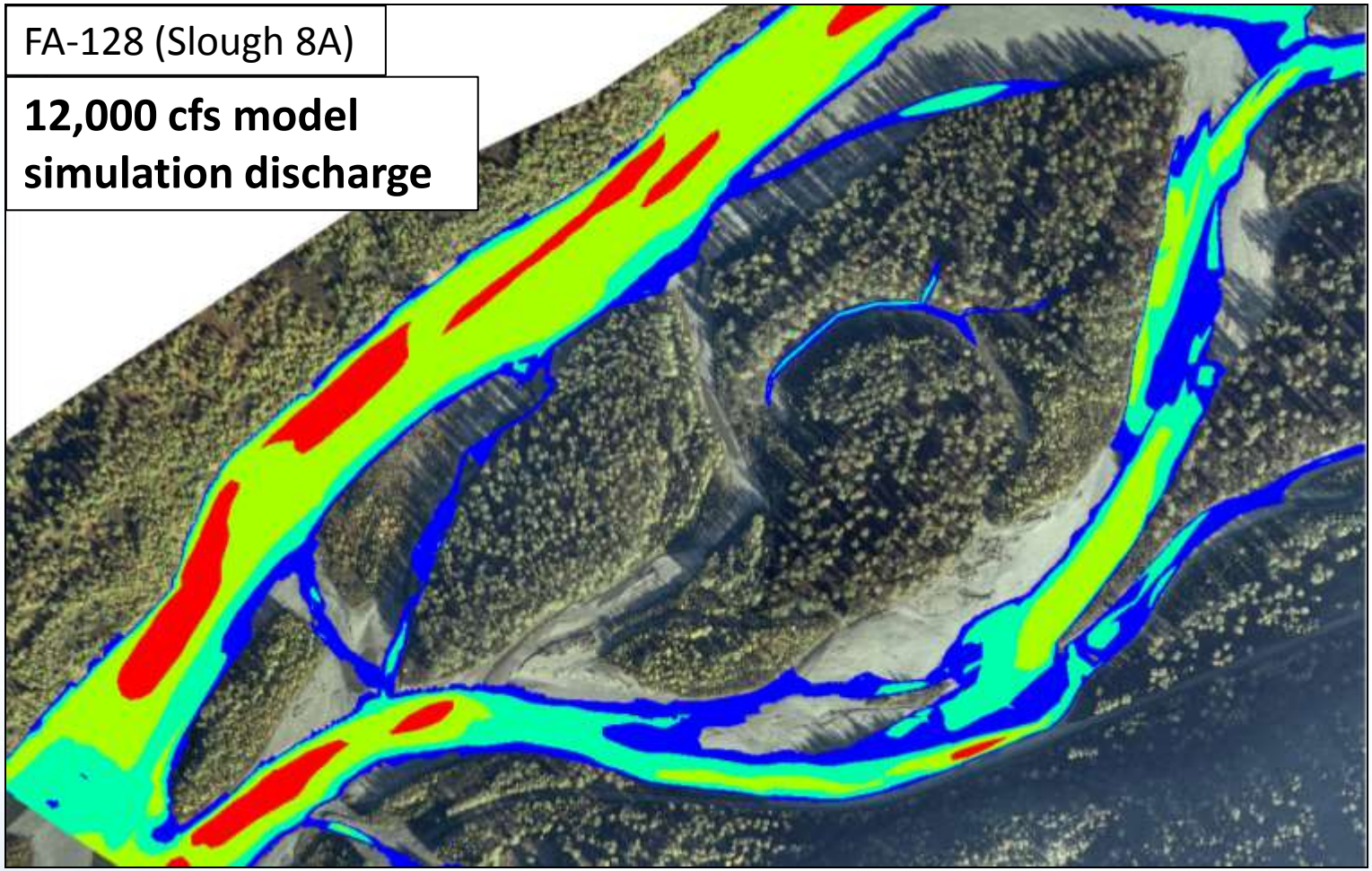
Surface/Ground Water Interactions



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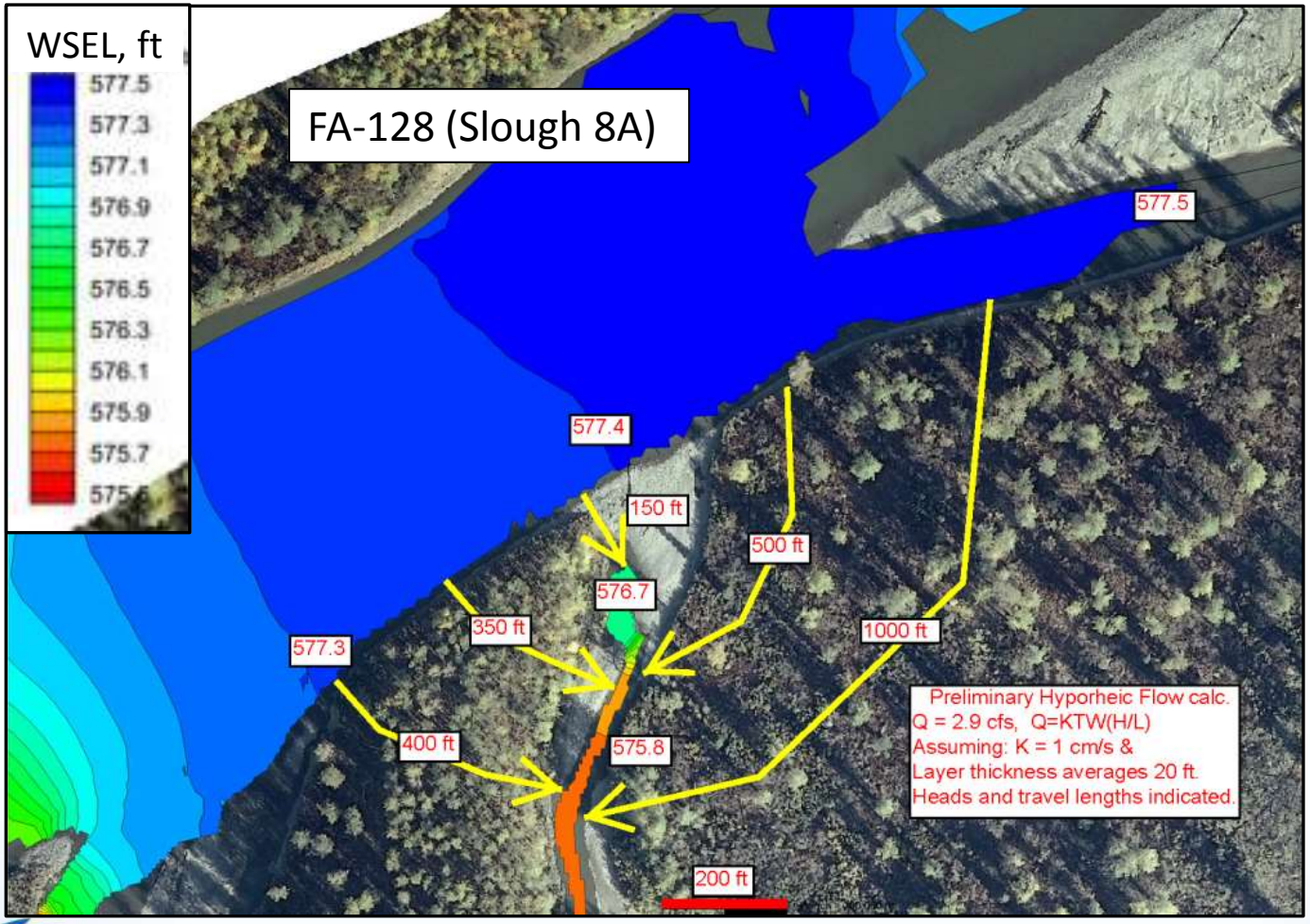
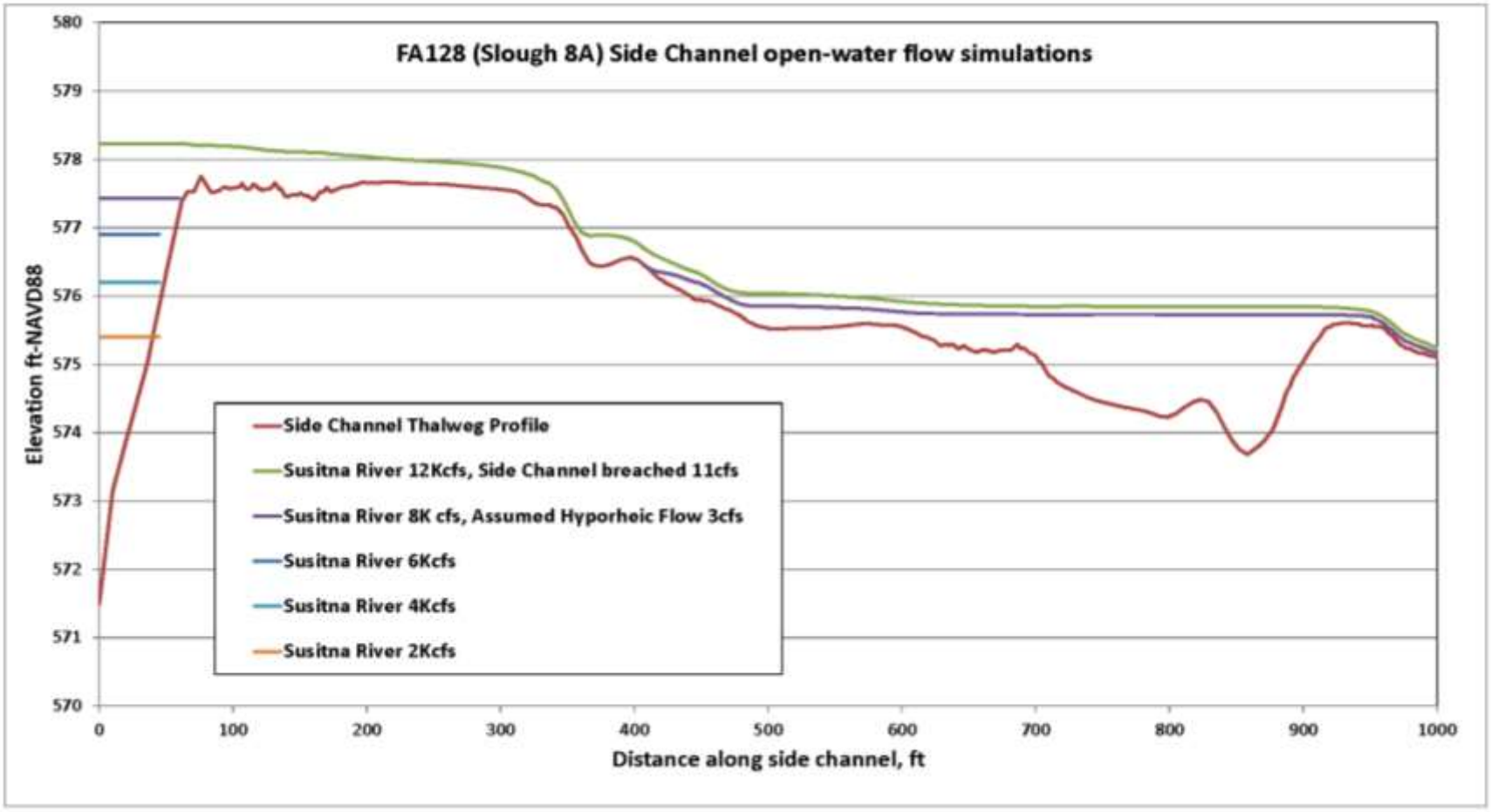
Surface/Ground Water Interactions

Hydraulic Model
8K cfs with 3 cfs point source



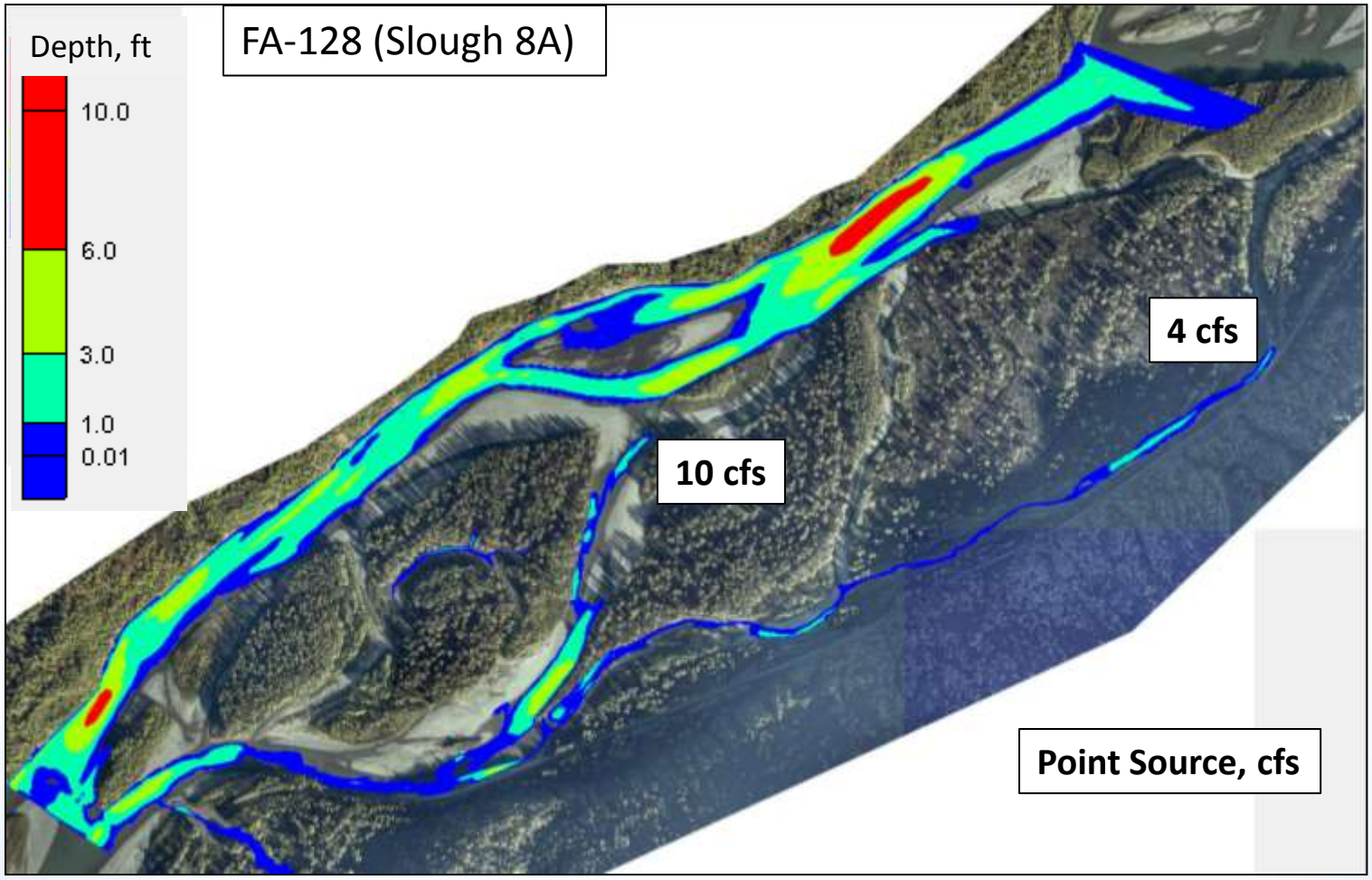
Hydraulic Model
8,000 cfs with 3 cfs point source



Surface/Ground Water Interactions

- Limitations
  - Groundwater may not correlate to surface water flows
  - Hyporheic flows correlate to surface water heads but time lagged – need mean conditions for steady-state SRH-2D runs
  - Sources and sinks present
  - Limited number of sources and sinks in SRH-2D

Hydraulic Model 2,000 cfs Depth



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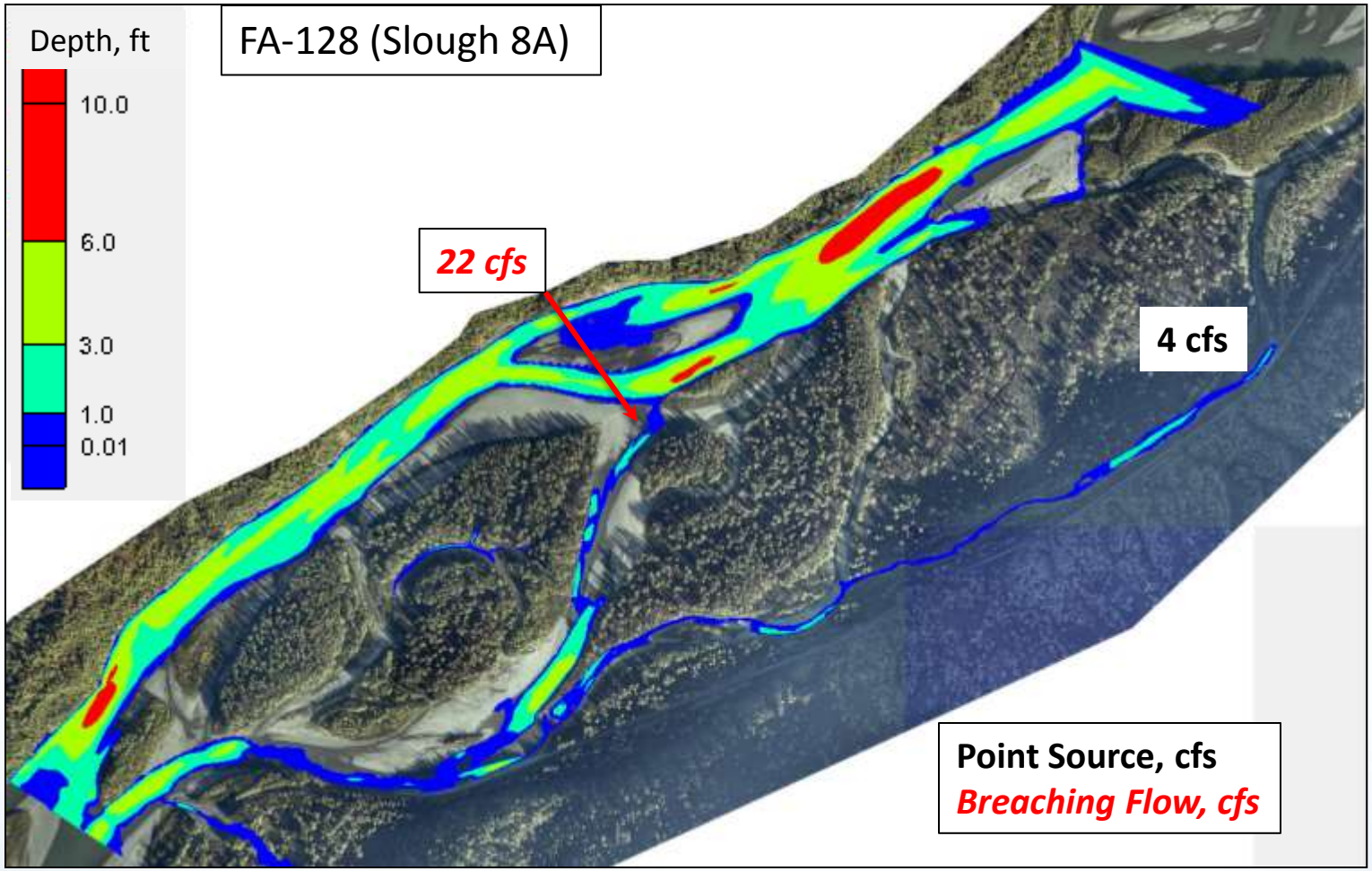
Hydraulic Model 4,000 cfs Depth



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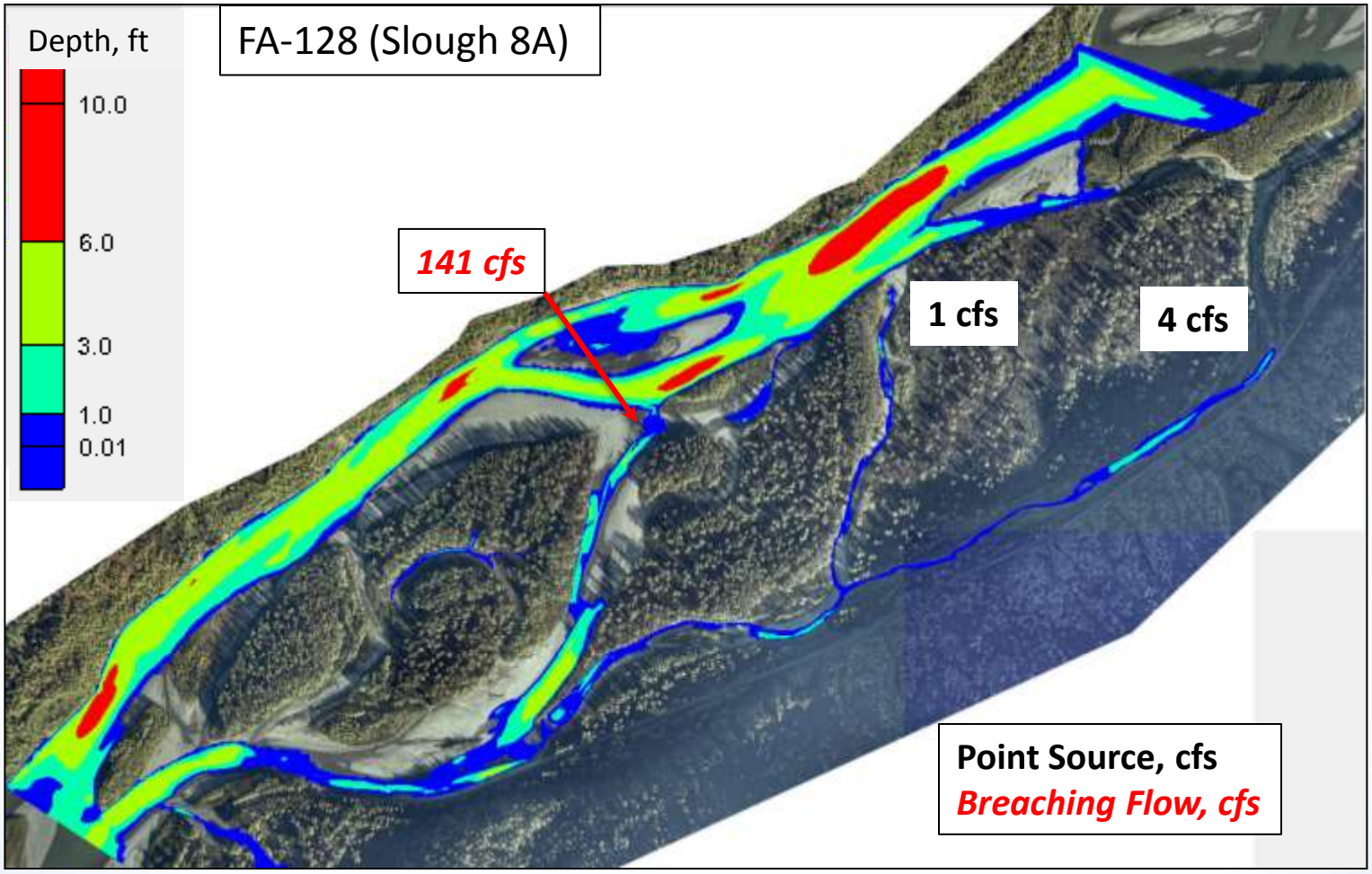
Hydraulic Model 6,000 cfs Depth



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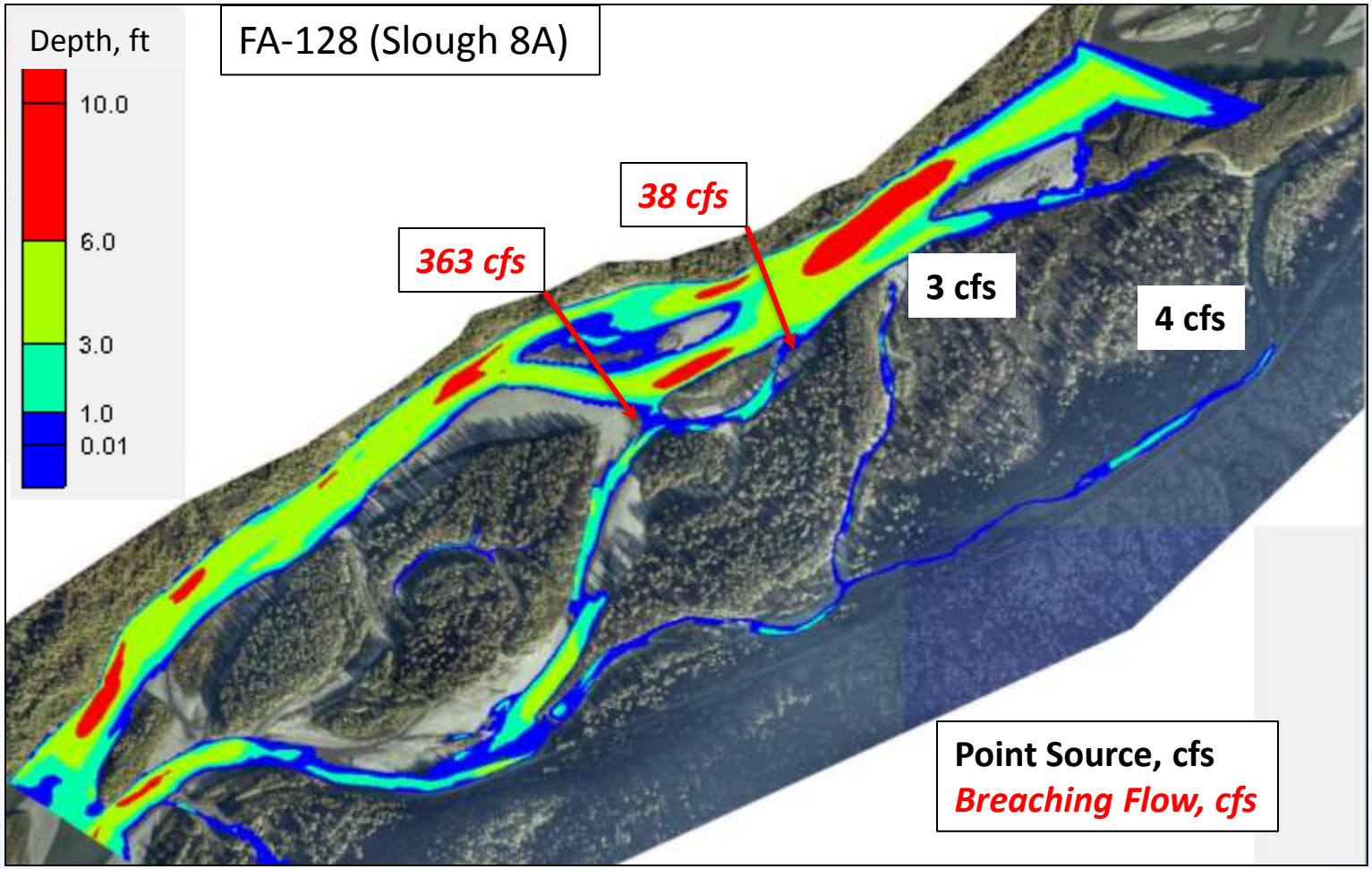
Hydraulic Model 8,000 cfs Depth



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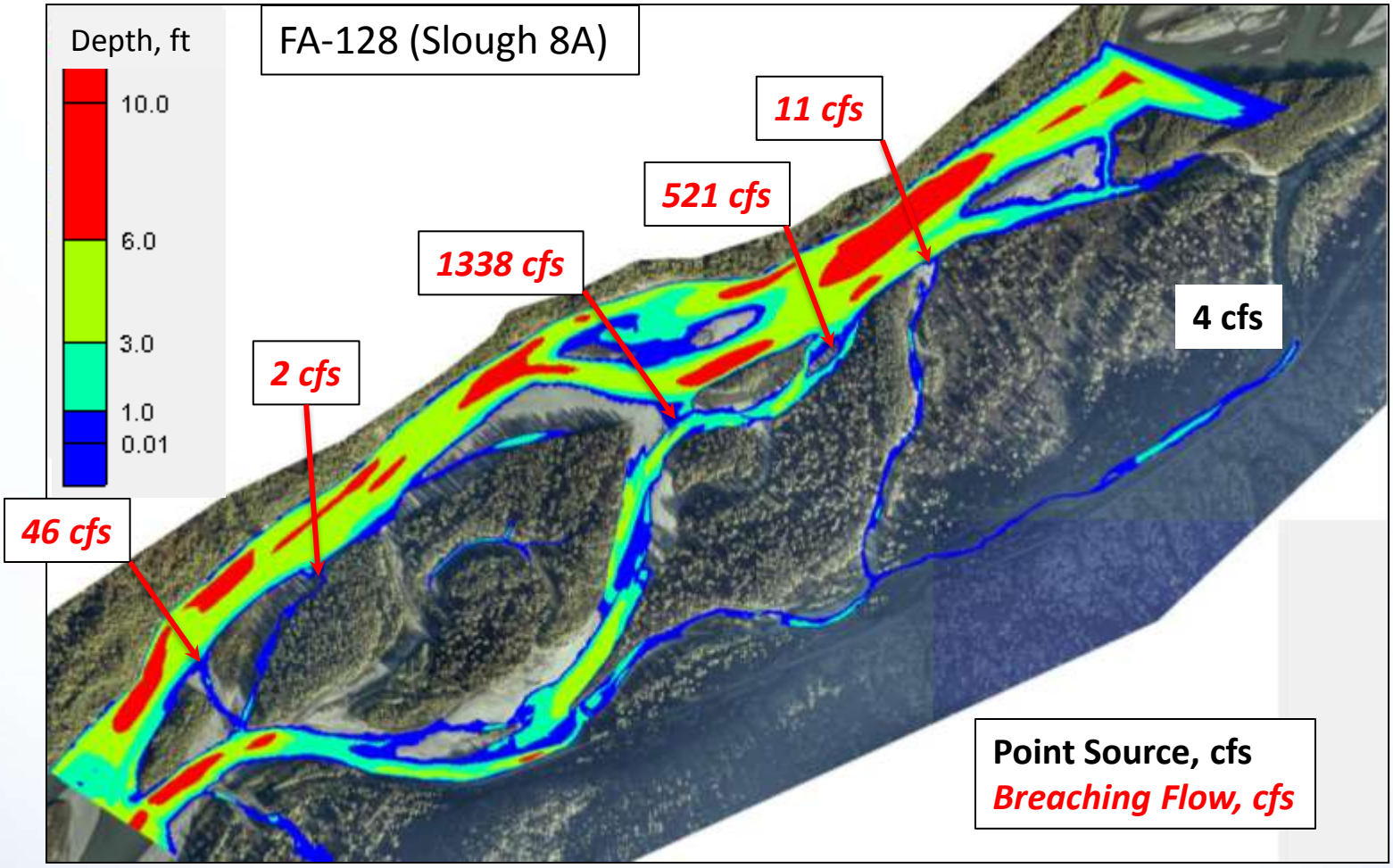
Hydraulic Model 12,000 cfs Depth



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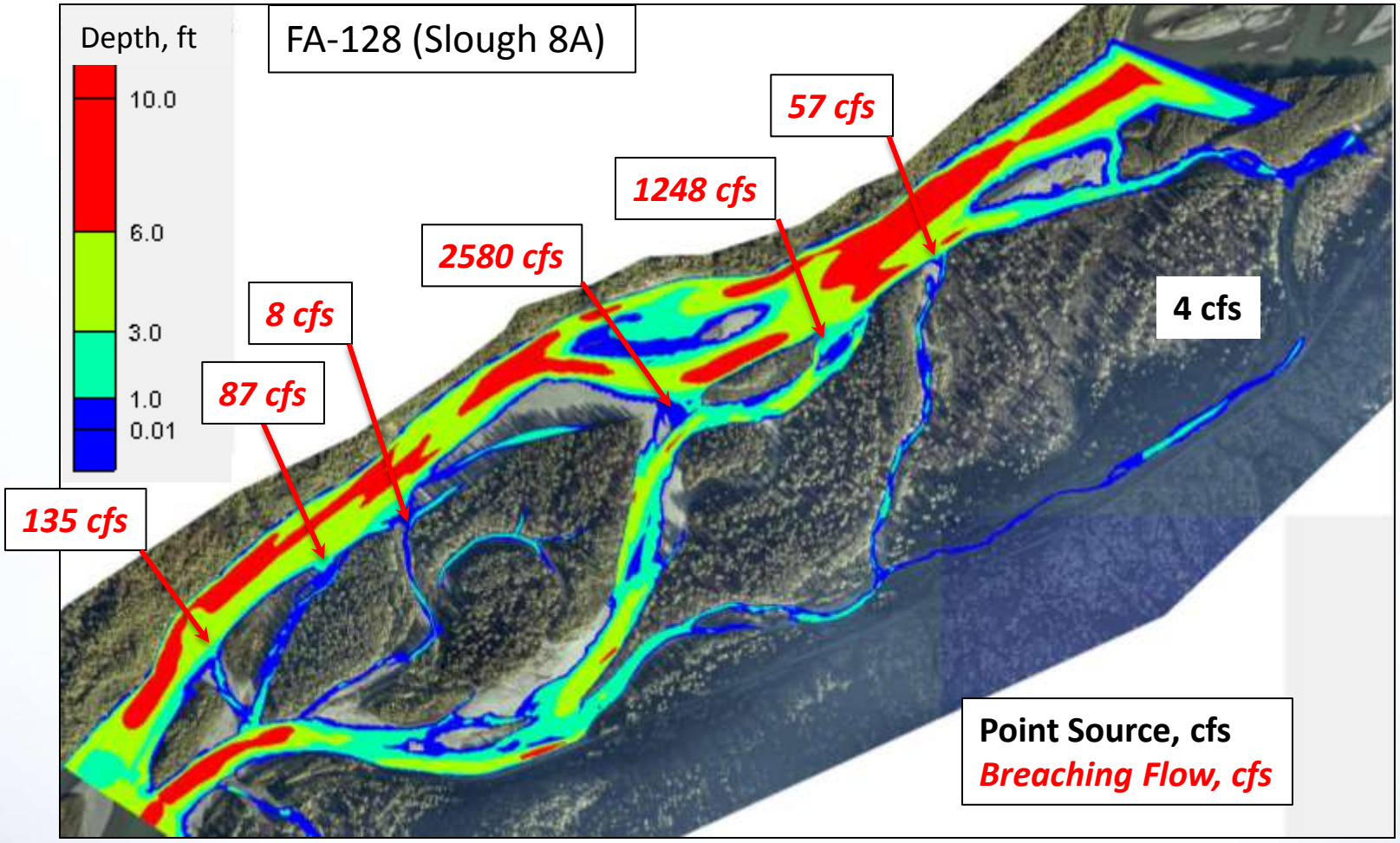
Hydraulic Model 16,000 cfs Depth



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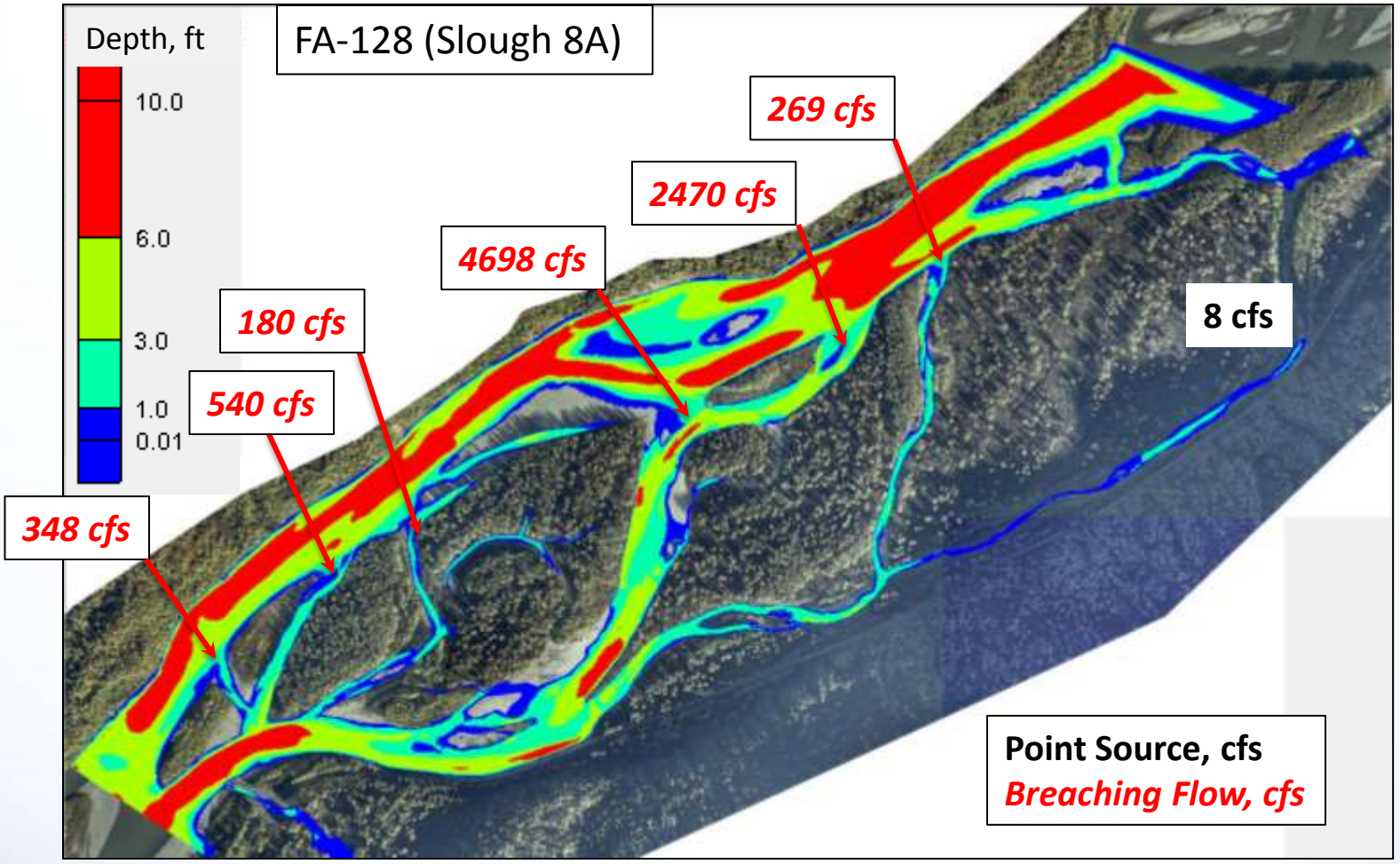
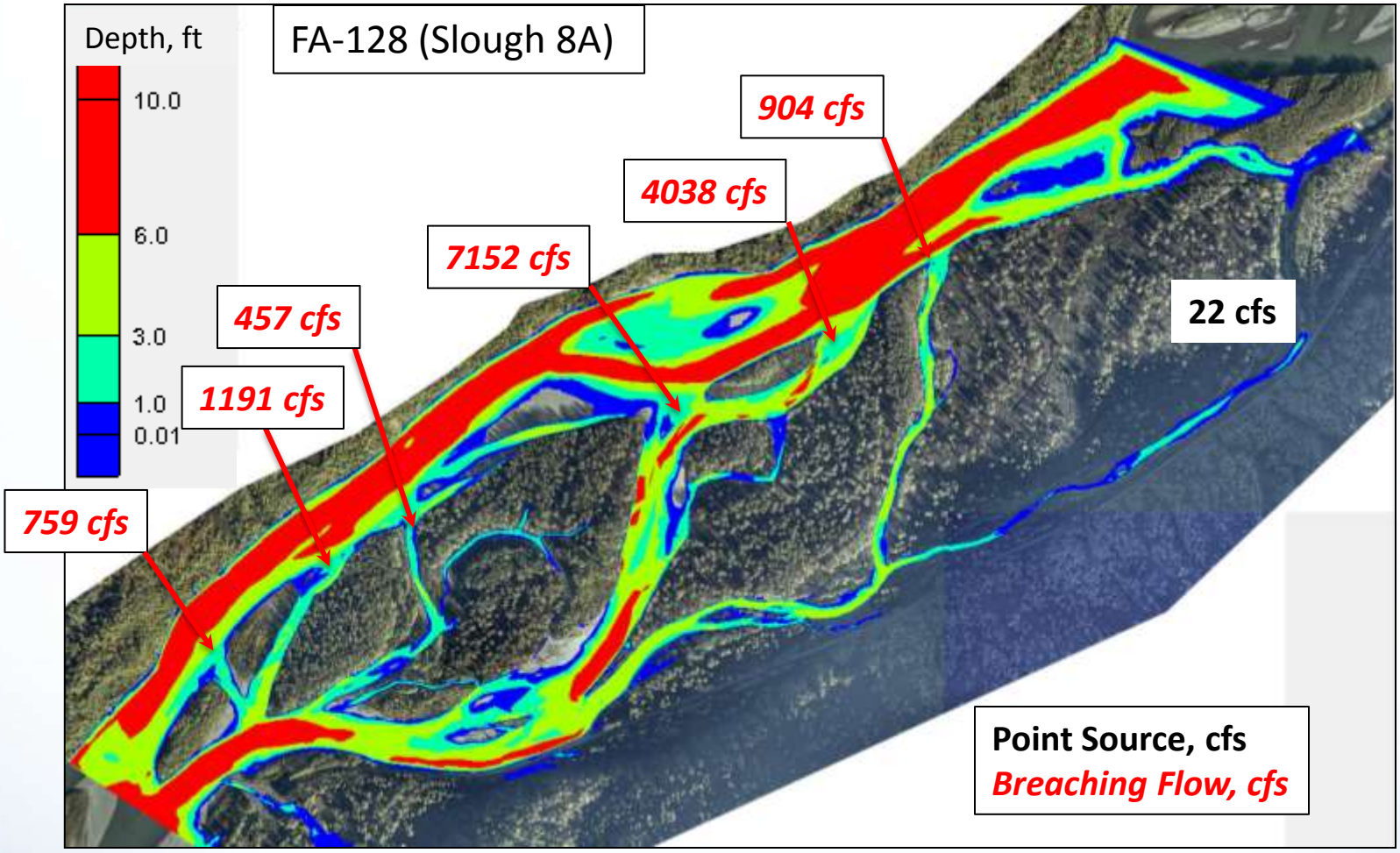
Hydraulic Model 22,000 cfs Depth



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

Hydraulic Model 30,000 cfs Depth



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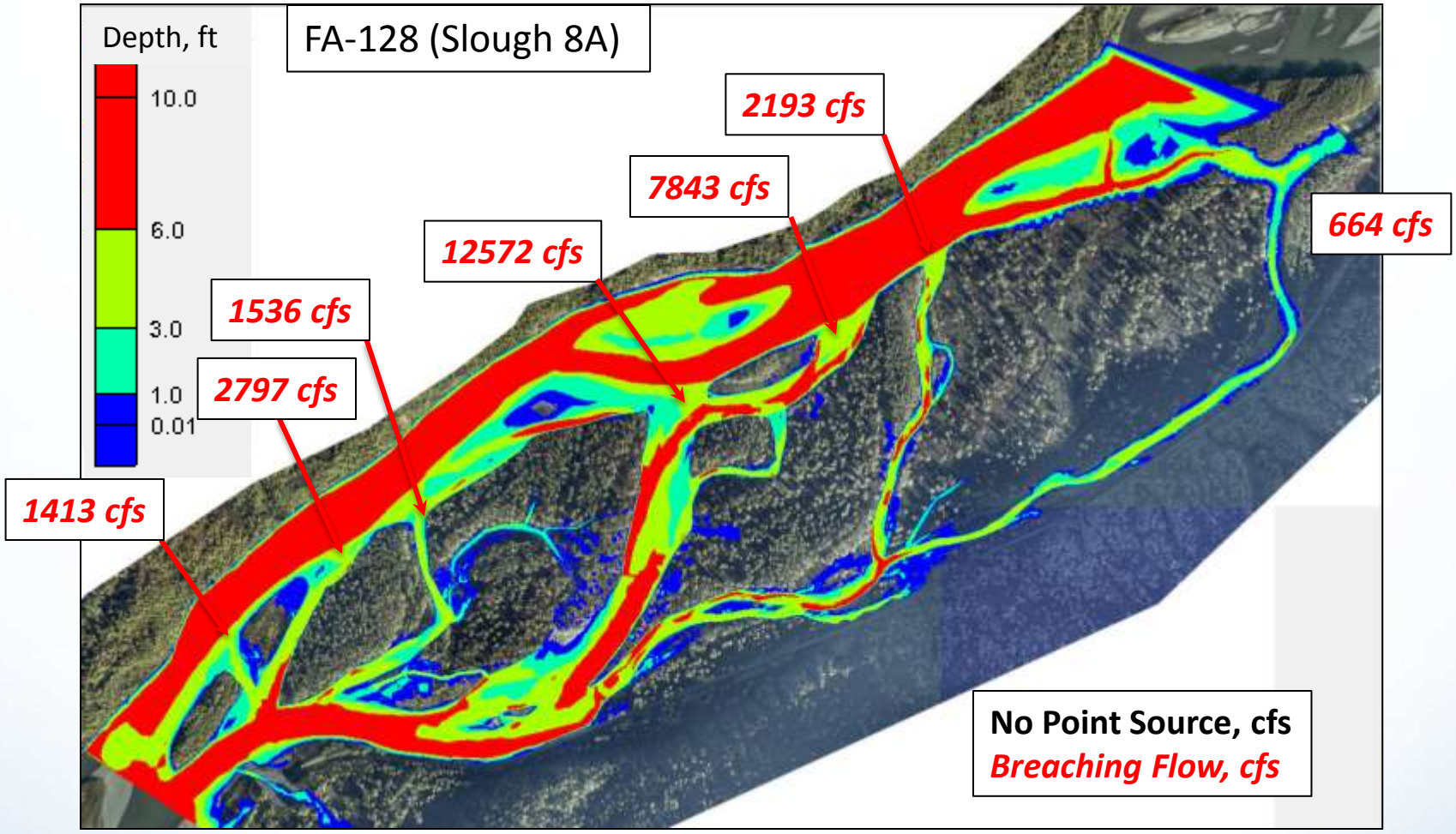
Hydraulic Model 50,000 cfs Depth



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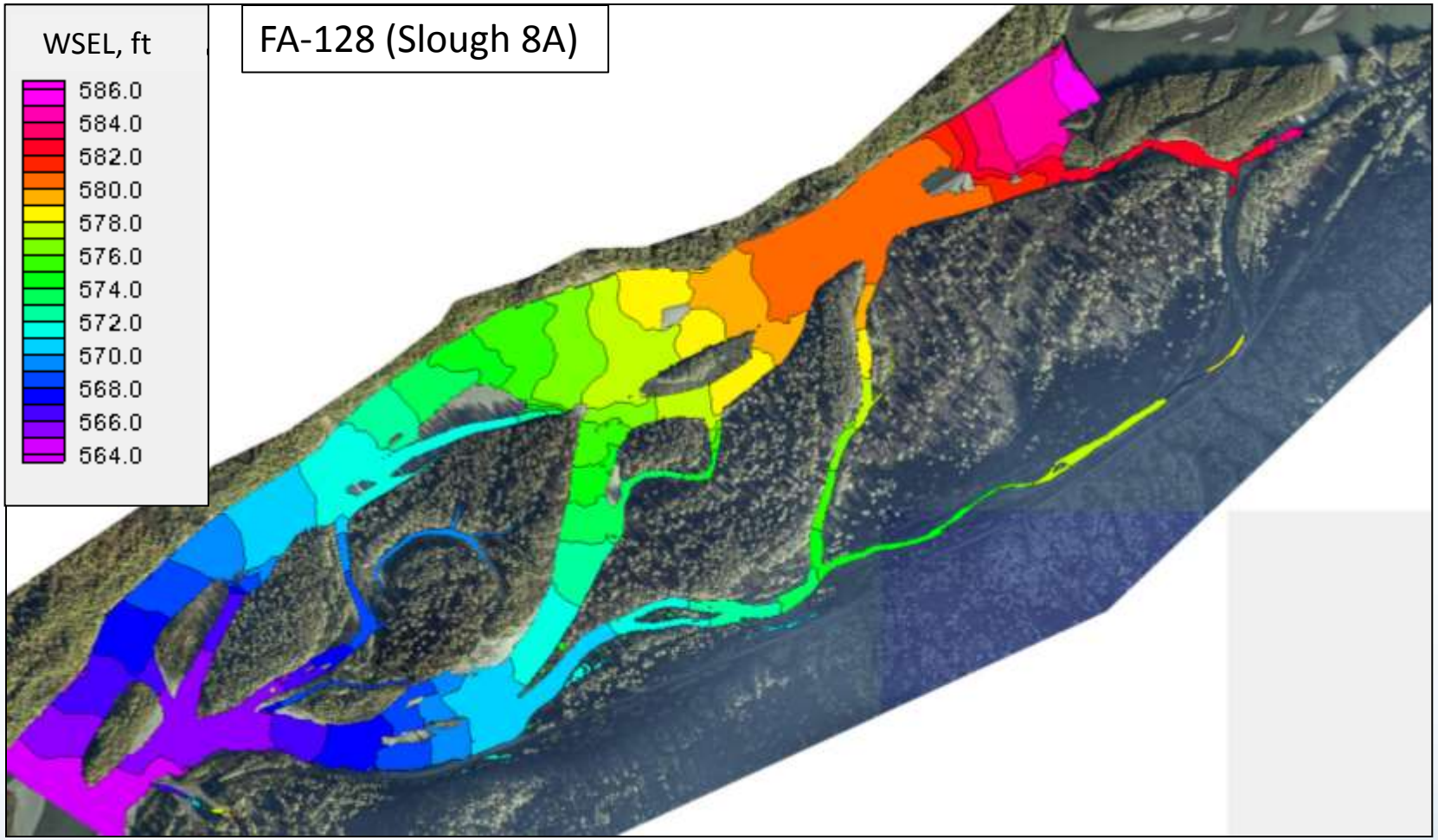
Hydraulic Model 30,000 cfs WSEL



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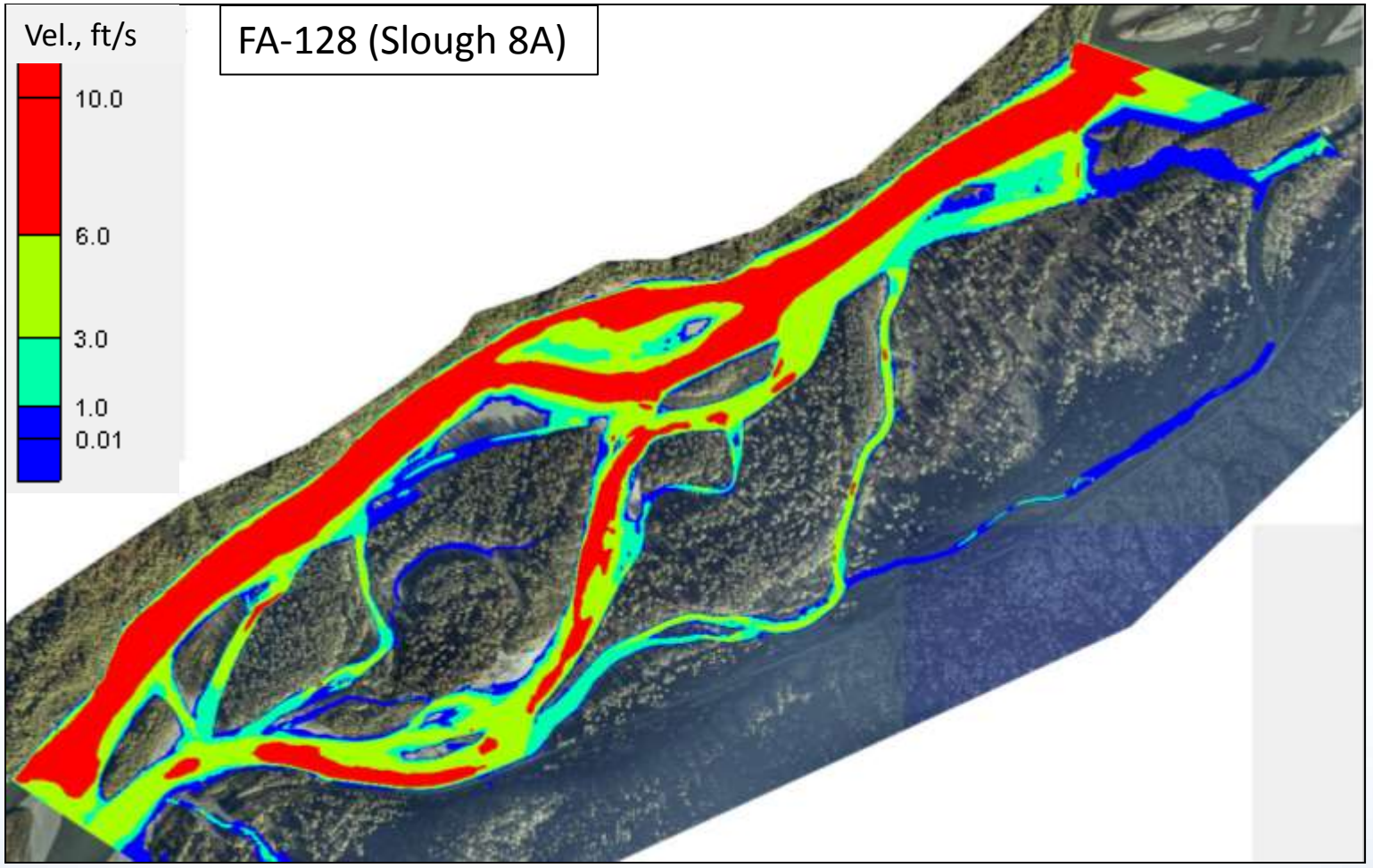
Hydraulic Model 30,000 cfs Velocity



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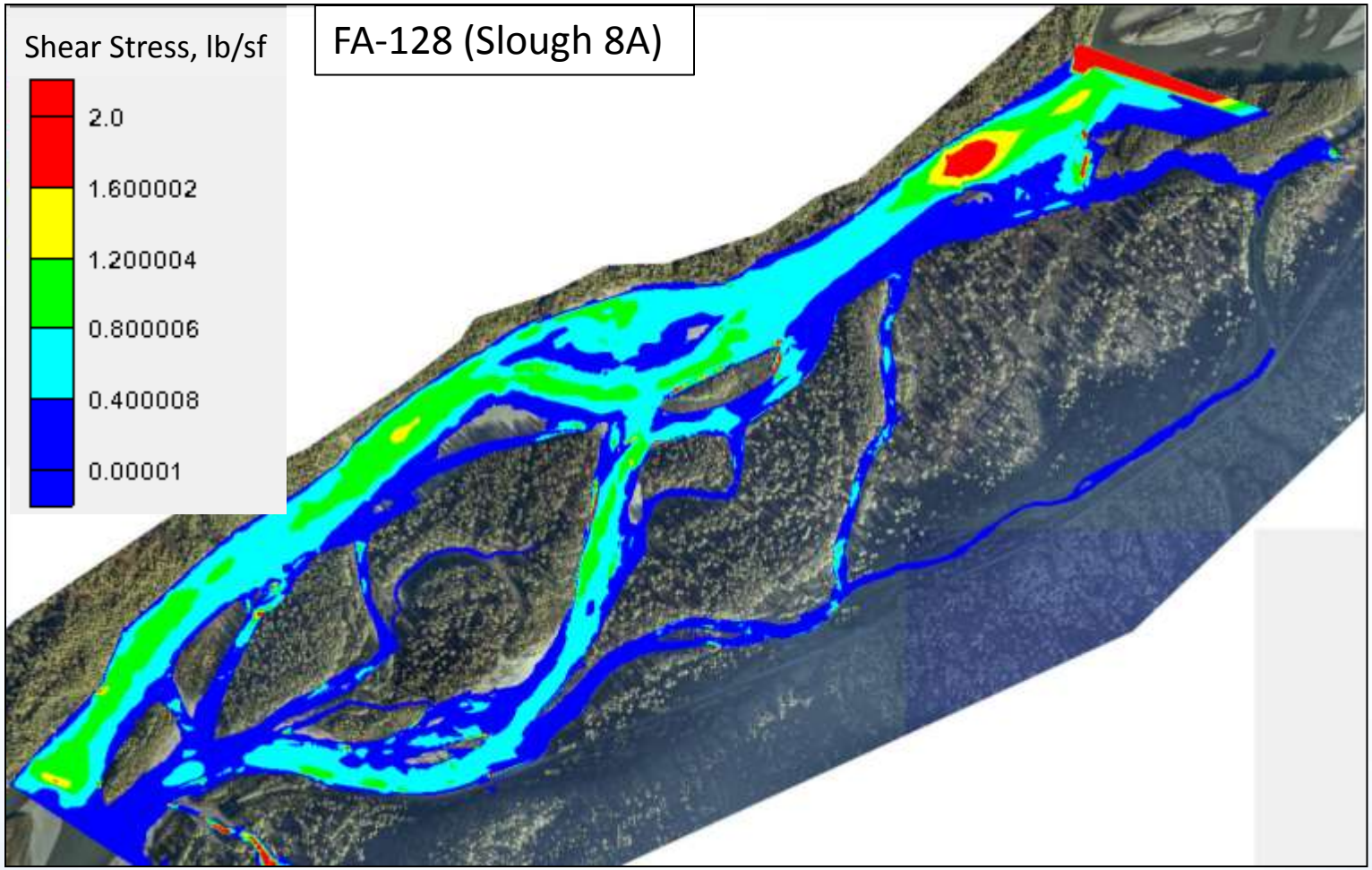
Hydraulic Model 30,000 cfs Shear



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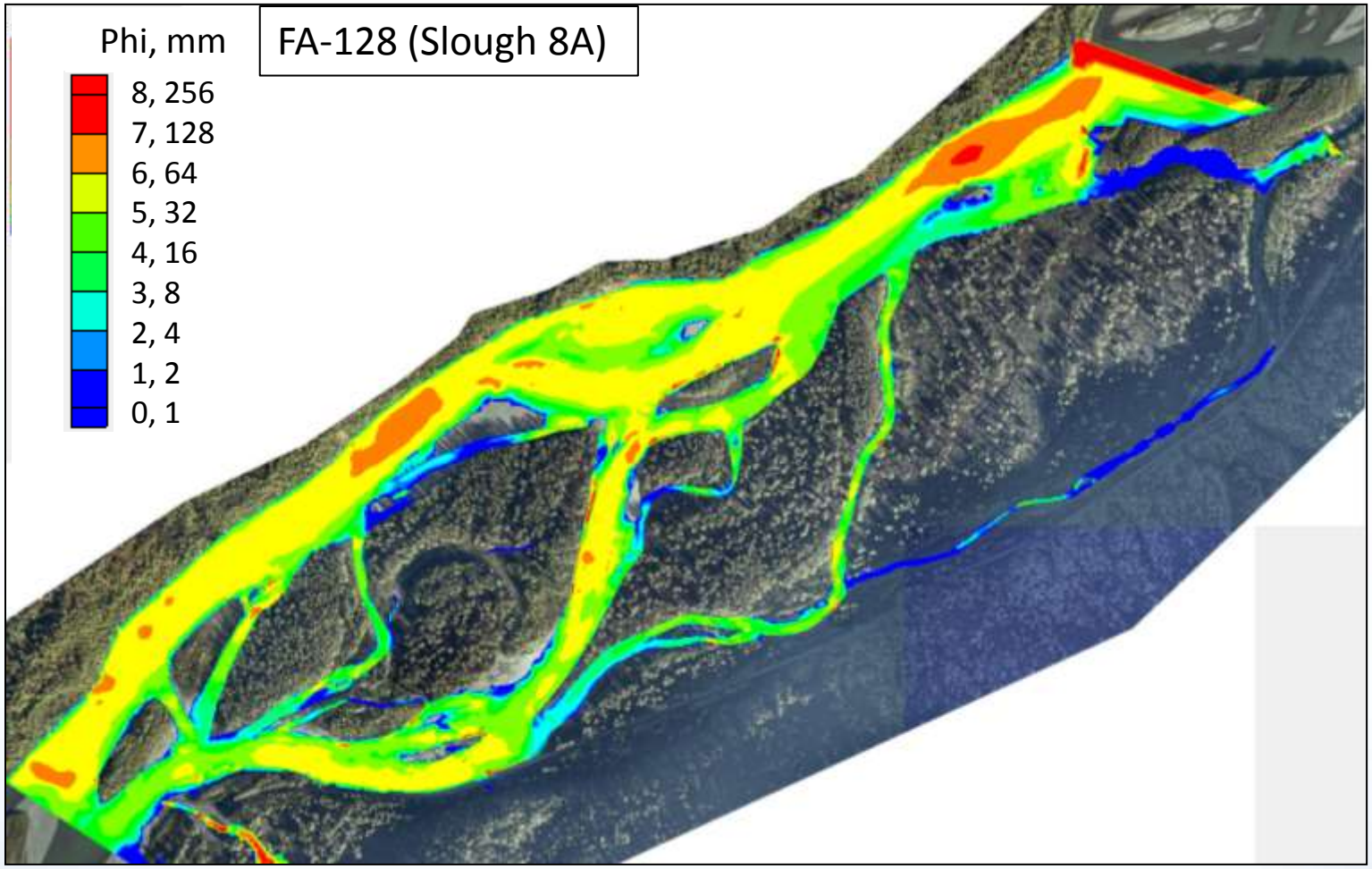
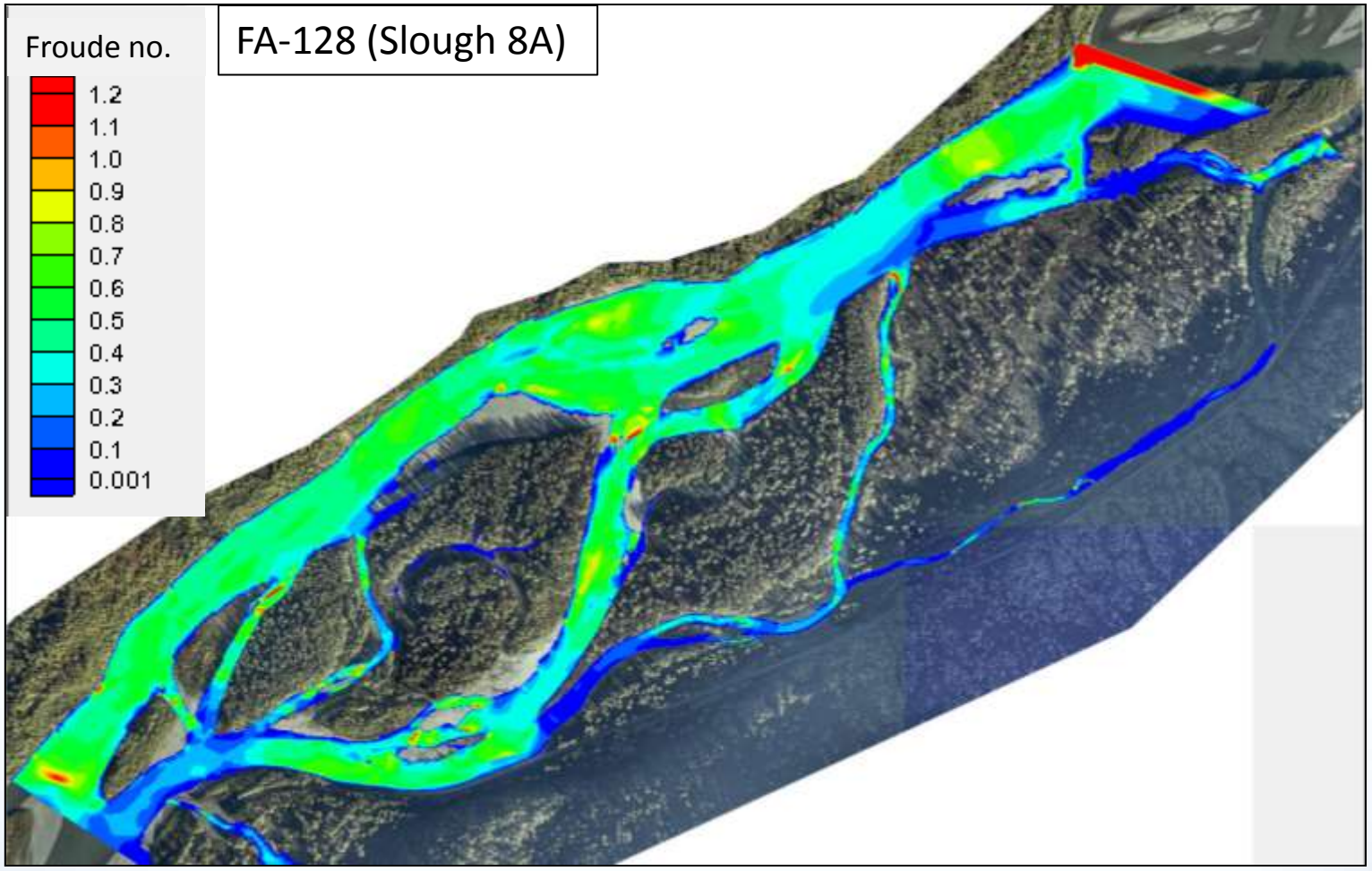
Hydraulic Model 30,000 cfs Dcrit-mm



Hydraulic Model 30,000 cfs Froude



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Next Steps

- Run Higher flows for Riparian Habitat
- Formalize approach for groundwater and hyporheic flow sources and sinks
- Confirm that bed shear and D_{crit} are representative in habitat areas