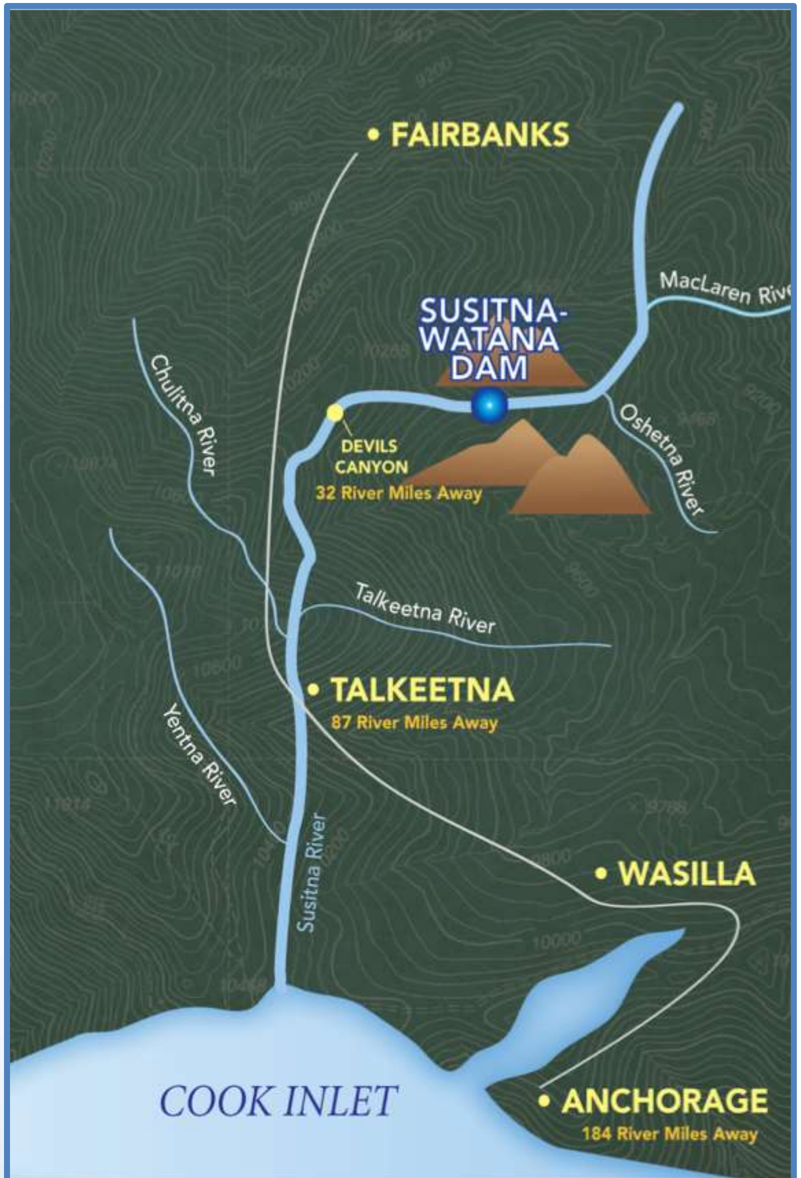


Technical Team Meeting

Riparian – IFS Modeling

Ice Processes Modeling

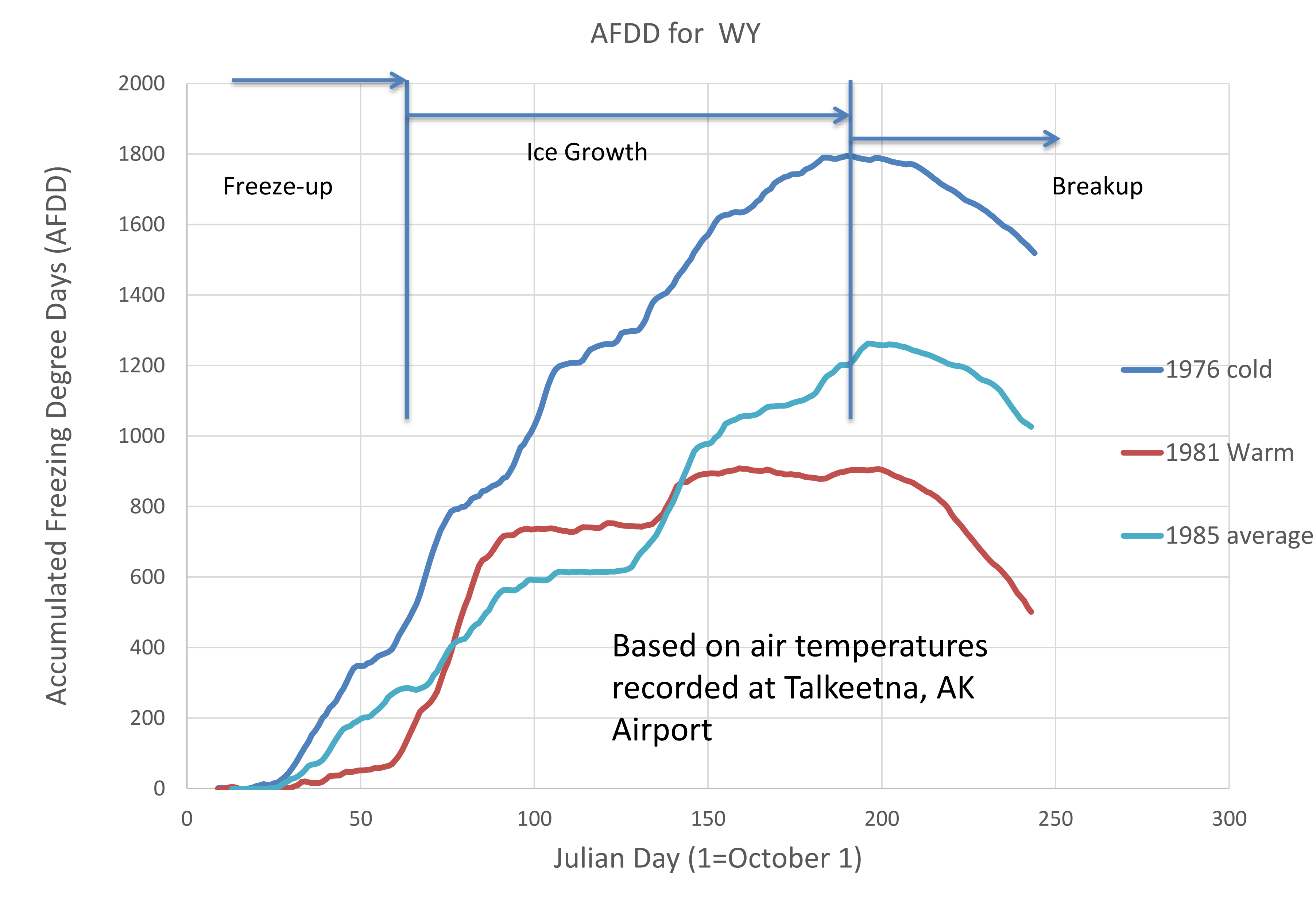
April 30, 2014

Prepared by HDR

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

Outcomes of the Riparian TT Meeting

- Understanding how ice processes impact the riparian ecosystem
- How to model ice actions along and in the floodplain
- What types of input data are available
- Description of the ice processes models
- How to evaluate the changes from existing conditions to the proposed load following
- How the ice modeling integrates with the other modeling efforts


AFDD for WY
Accumulated Freezing Degree Days (AFDD)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Freeze-up
Ice Growth
Breakup
1976 cold
1981 Warm
1985 average
Based on air temperatures recorded at Talkeetna, AK Airport
0
50
100
150
200
250
300
Julian Day (1=October 1)

Impacts on Freeze-up Processes
ESS40 at PRM 106.8

Impacts on Freeze-up Processes
ESS40 at PRM 106.8

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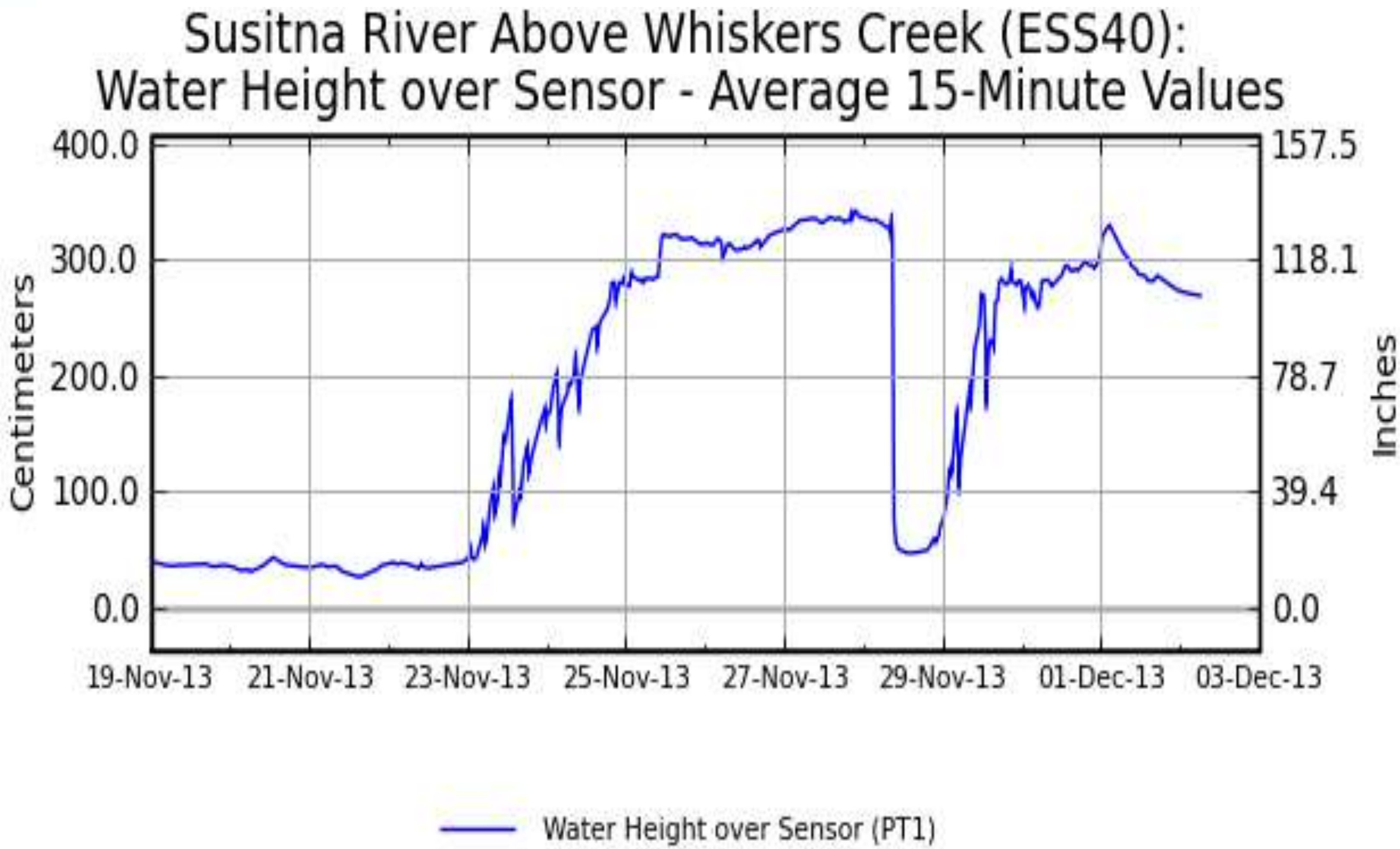
Impacts on Freeze-up Processes
ESS40 at PRM 106.8

Impacts on Freeze-up Processes
ESS40 at PRM 106.8



Slough 8A, PRM 127.9
Freeze-up 2012

SUSITNA-WATA

Slough 8A, PRM 127.9
Breakup 2013

SUSITNA-WATAN

Slough 8A, PRM 127.9
Breakup 2013

SUSITNA-WATANA

Devils Canyon

- Frazil ice generation
- Frazil transport
- Massive frazil accumulations
- Jamming and re-jamming
- Difficult to model
- Little riparian area

2013 Breakup Observations – Slough 9 PRM 132.8

- Islands and bars inundated
- Vegetation damaged
- Ice scour
- Sediment deposition

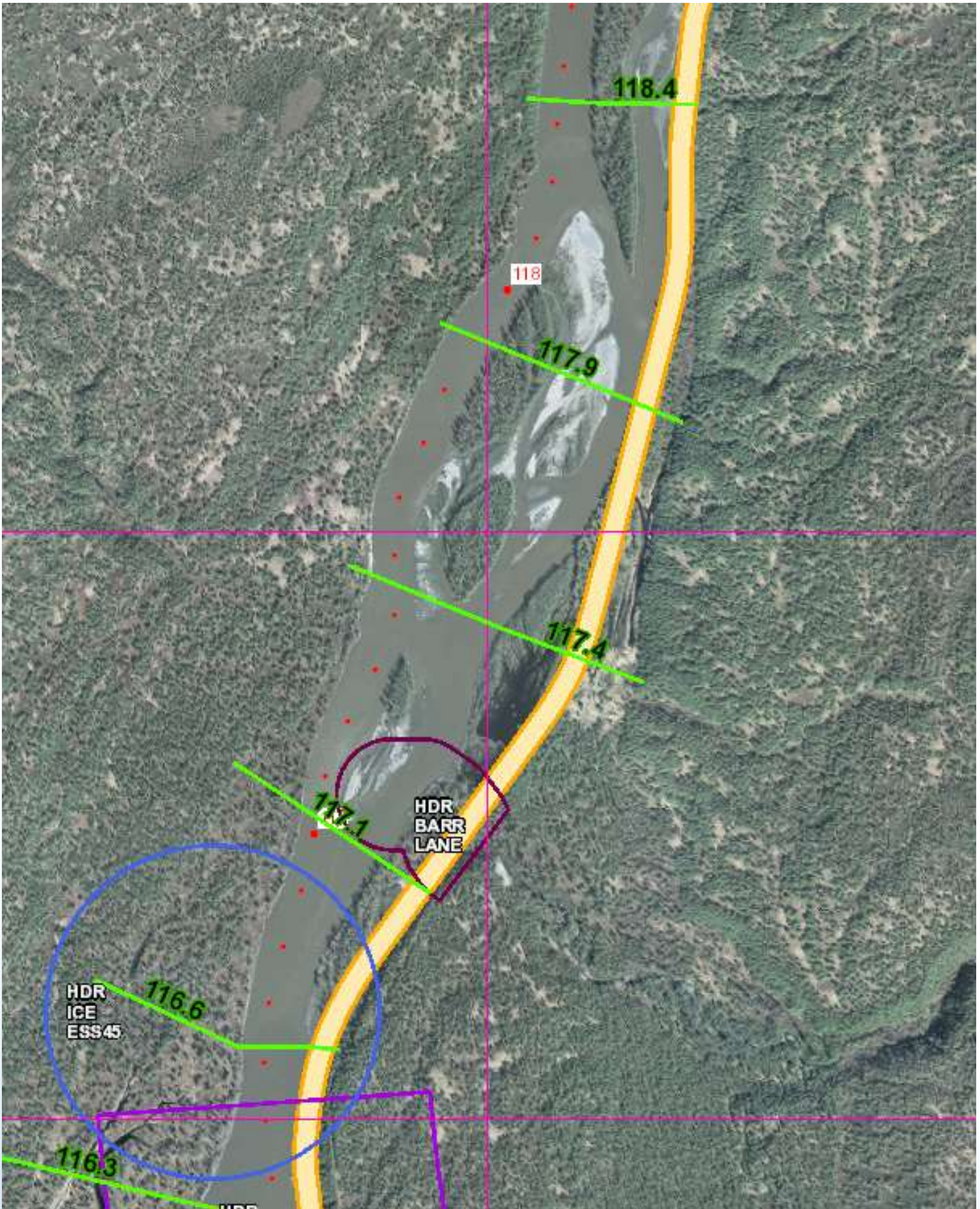
Historical Observations Assist Model Calibration

PRM 132.4 - Ice deposited in Slough 9. May 29th, 2013.

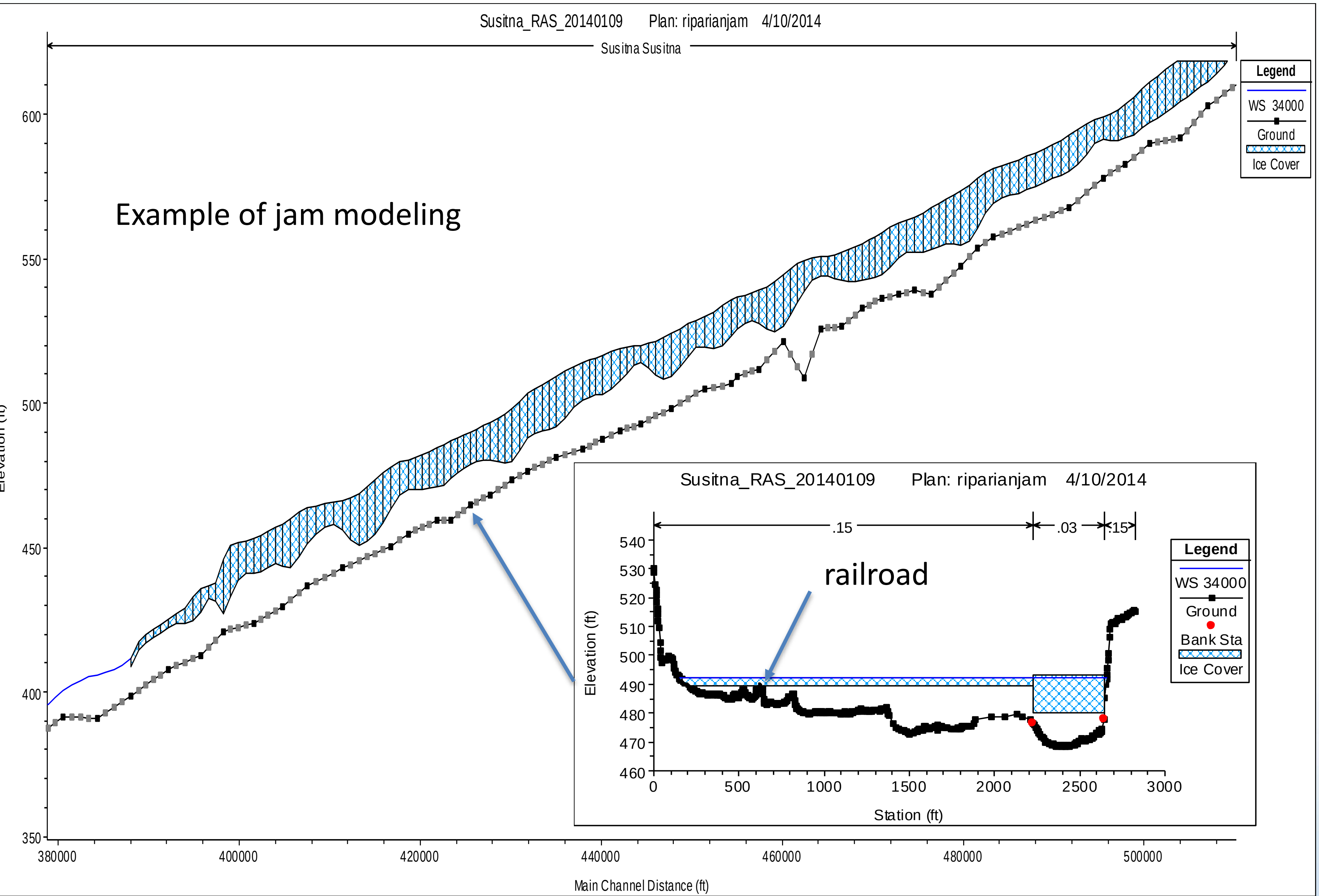
Photo provided by ARRC


5/18/2002
Photo provided
By ARRC
18 11:31AM


About PRM 117.4
05.04.2009



- Railroad alignment from previous slide
- Ice impacted rails
- Water levels high enough to pass ice into floodplain over tracks
- X-section 117.4


Susitna_RAS_20140109 Plan: riparianjam 4/10/2014
Susitna Susitna
Legend
WS 34000
Ground
Ice Cover
Example of jam modeling
Elevation (ft)
Main Channel Distance (ft)
Susitna_RAS_20140109 Plan: riparianjam 4/10/2014
.15
.03
.15
railroad
Legend
WS 34000
Ground
Bank Sta
Ice Cover
Elevation (ft)
Station (ft)

River1D Ice Modeling

- *River1D is a one dimensional hydraulic flood routing model*
- *Includes dynamic ice*
- *Provides output at specific cross section locations*
- *Bulk properties (1D output values) provide input and boundary conditions for River2D*
- *1D unsteady processes can be stepped through in the 2D model*

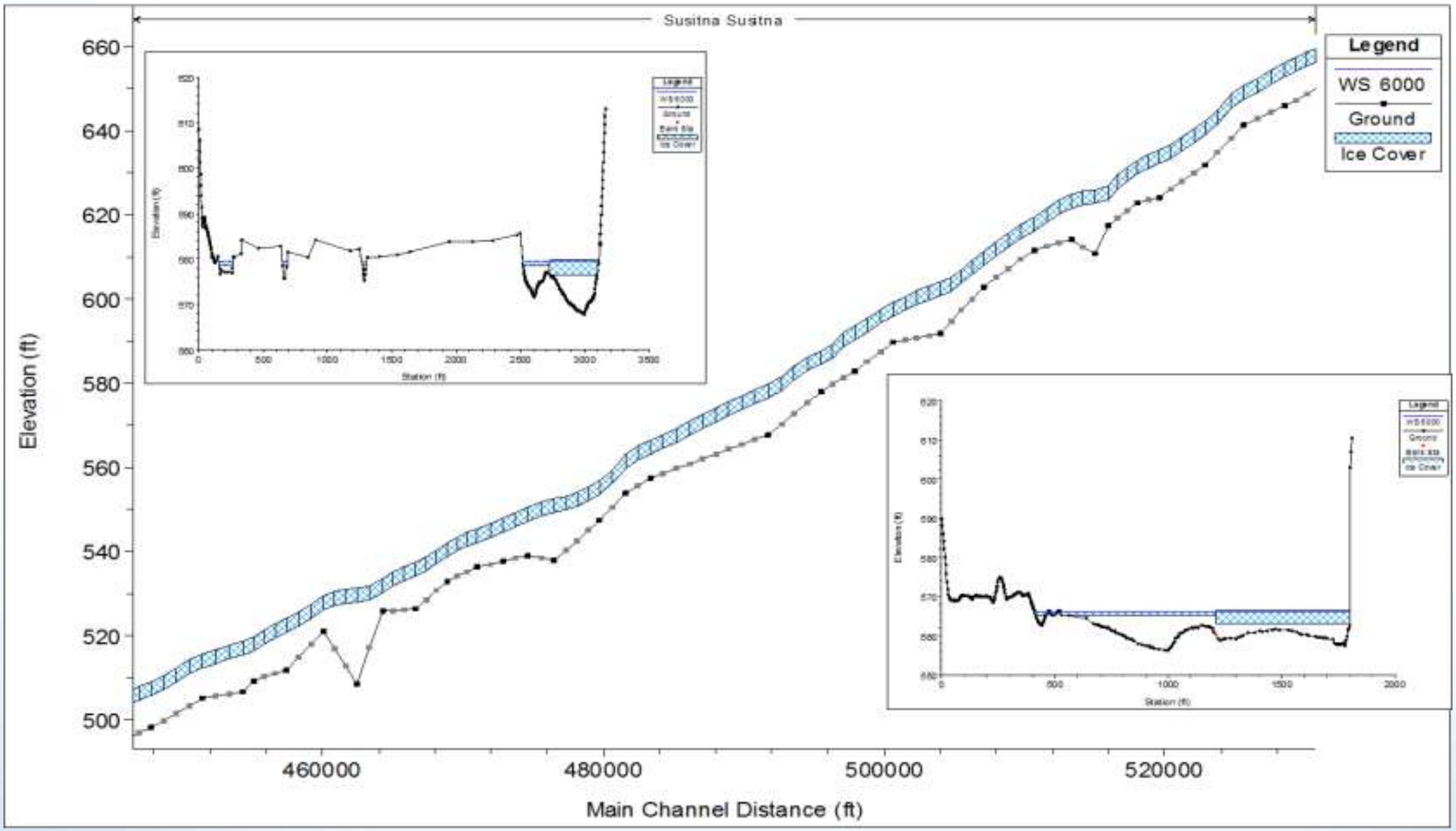
River1D Ice Modeling

- *Water temperature cool down*
  - *Function of air temperature, water temperature, wind, solar radiation, open water area, discharge*
- *Frazil ice formation*
  - *Function of air temperature, wind, open water area*
- *Frazil ice transport*
  - *Function of discharge, open area, existing covers*
- *Ice accumulation*
  - *Function of air temperature, velocity, river geometry*
- *Ice growth*
  - *Function of air temperature, snow cover*
- *Jam failure and movement/re-jamming*
  - *Function of discharge, under ice shear, ice strength*

River1D Ice Modeling

1D dynamic ice modeling FA-128 (Slough 8A)

6000 cfs, freeze-up ice cover on main channel

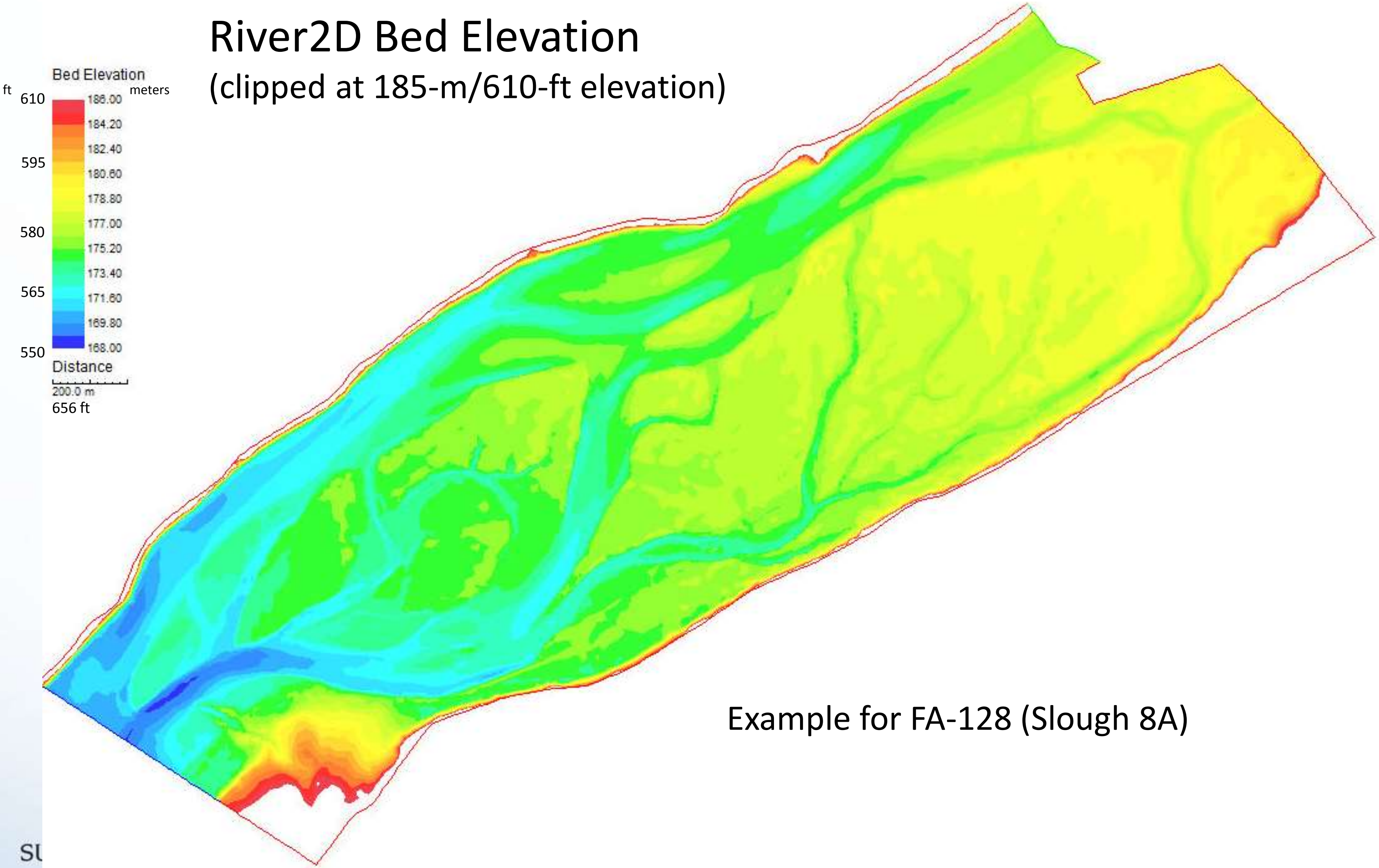


River2D Ice-Cover Model Overview

- *Two-dimensional depth-averaged model*
- *Spatially variable, triangular, finite-element grid*
  - *Fine spatial resolution*
  - *Detailed bathymetry*
- *Channel resistance*
  - *Manning's n*
  - *Roughness height*
- *Simulates steady or unsteady flows*
- *Wetting and drying (floodplain inundation)*

River2D Bed Elevation

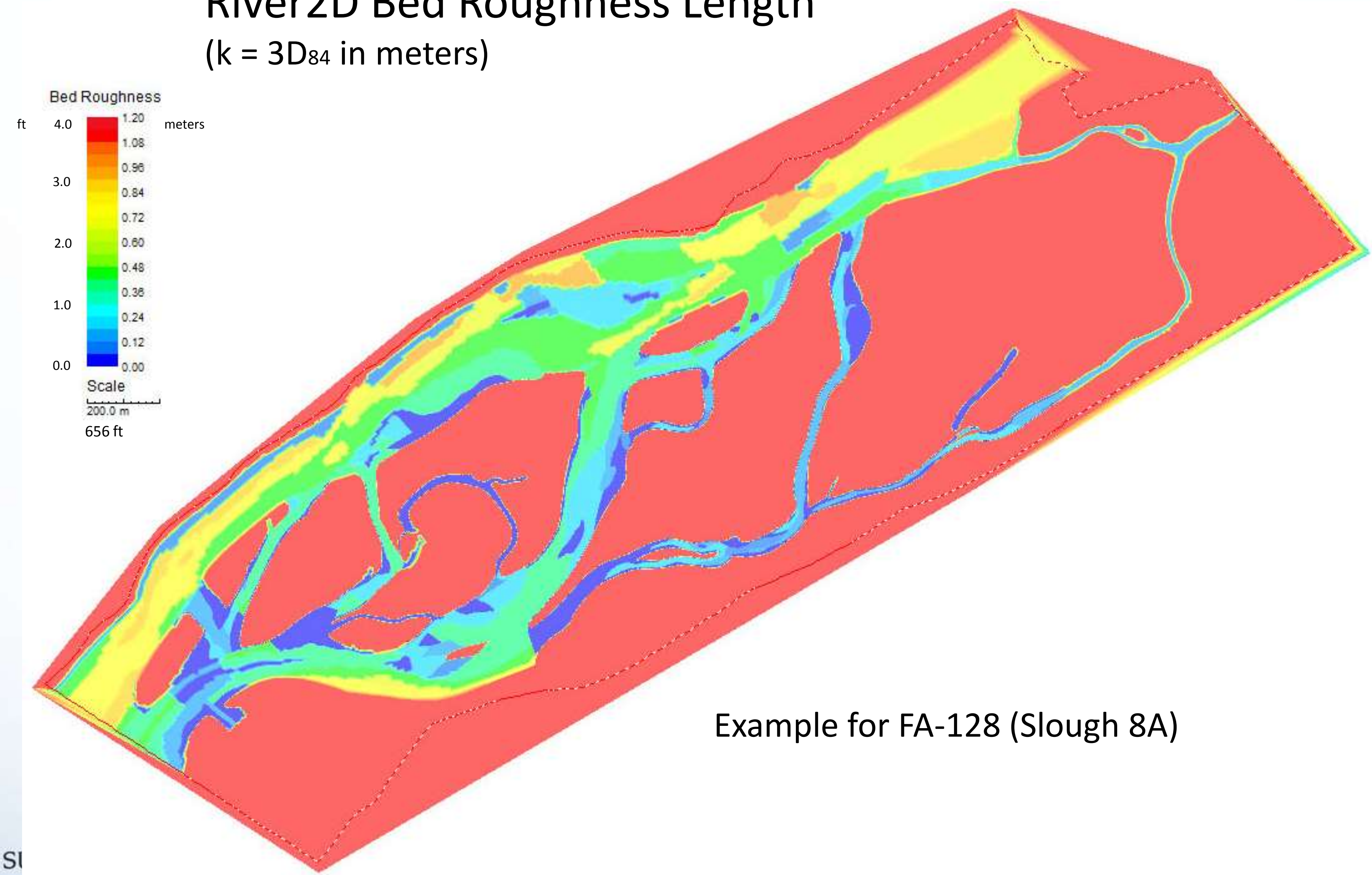
(clipped at 185-m/610-ft elevation)



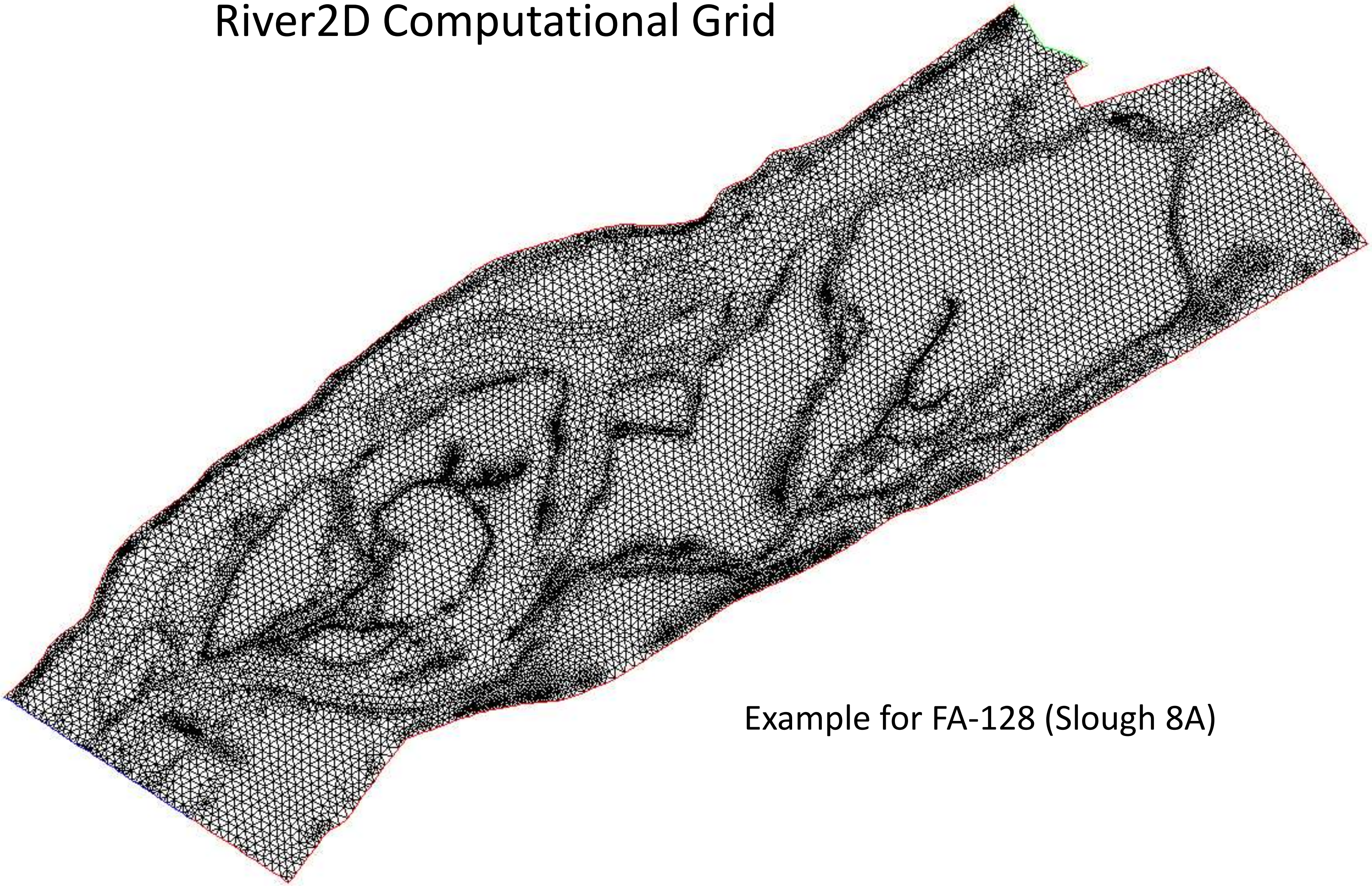
Example for FA-128 (Slough 8A)

River2D Bed Roughness Length

(k = 3D84 in meters)



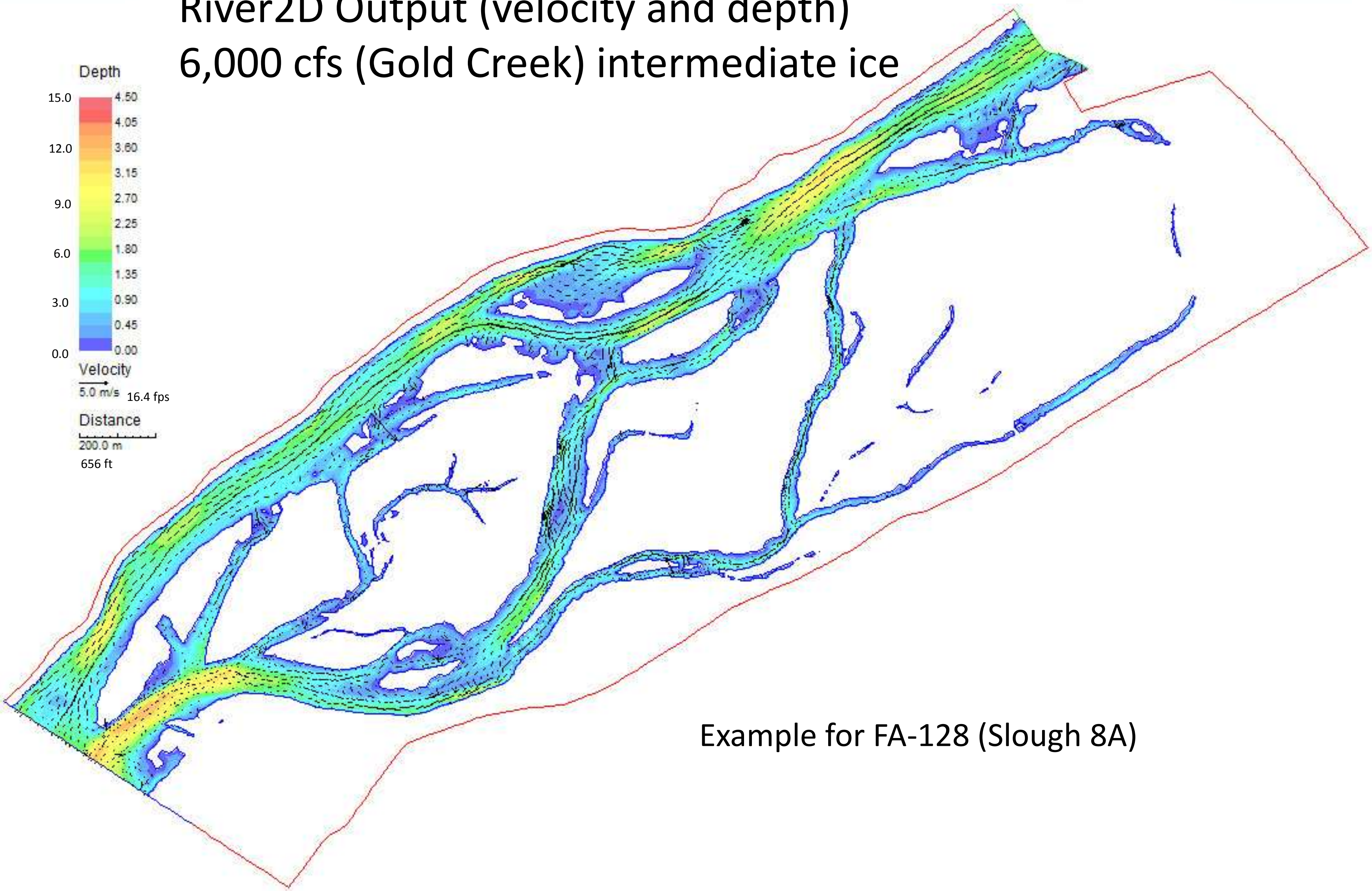
River2D Computational Grid



Example for FA-128 (Slough 8A)

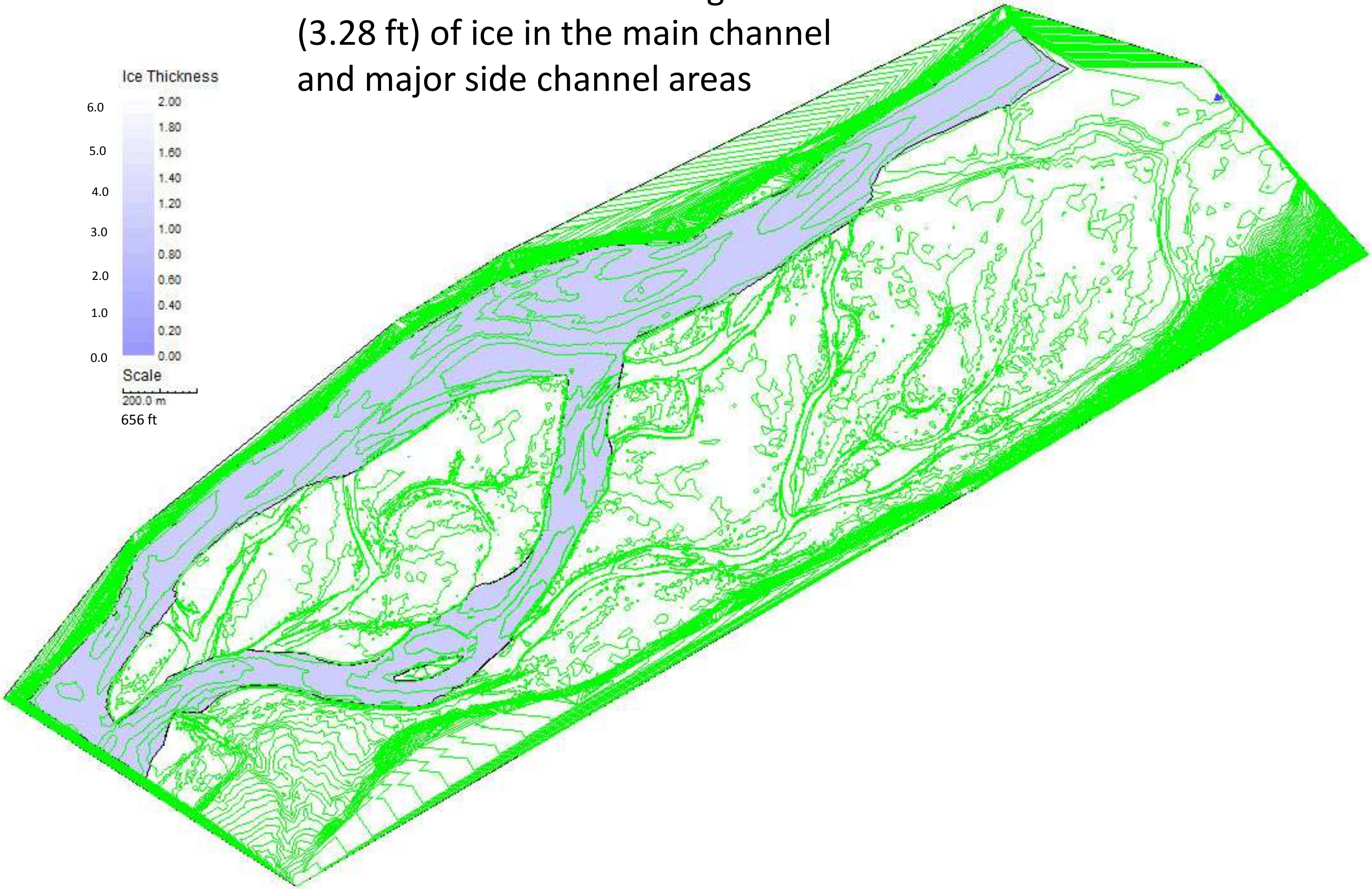
FA-128 (Slough 8A) on December 3, 2012
intermediate ice conditions, <6,000 cfs (Gold Creek)

River2D Output (velocity and depth)
6,000 cfs (Gold Creek) intermediate ice

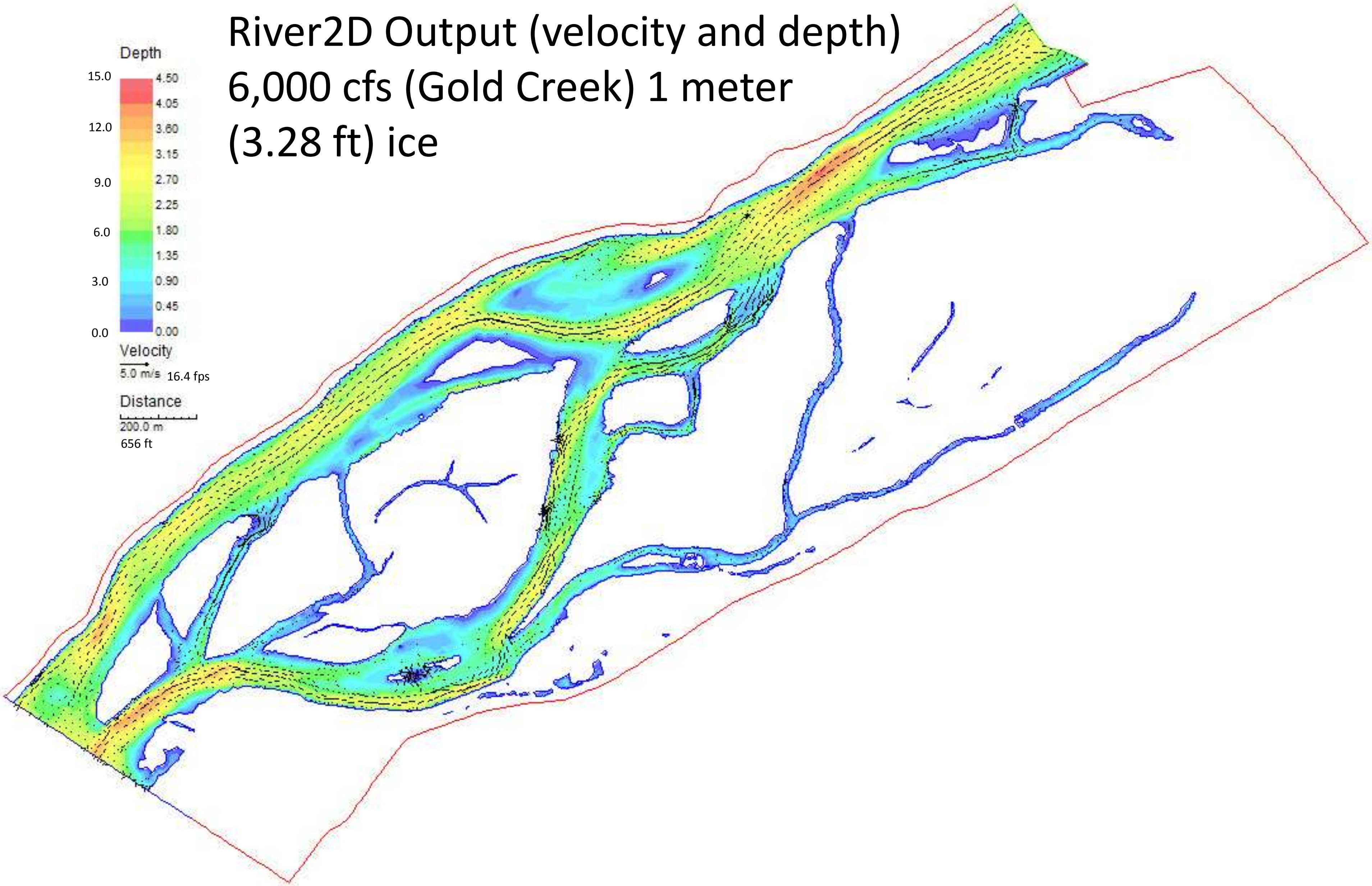


Example for FA-128 (Slough 8A)

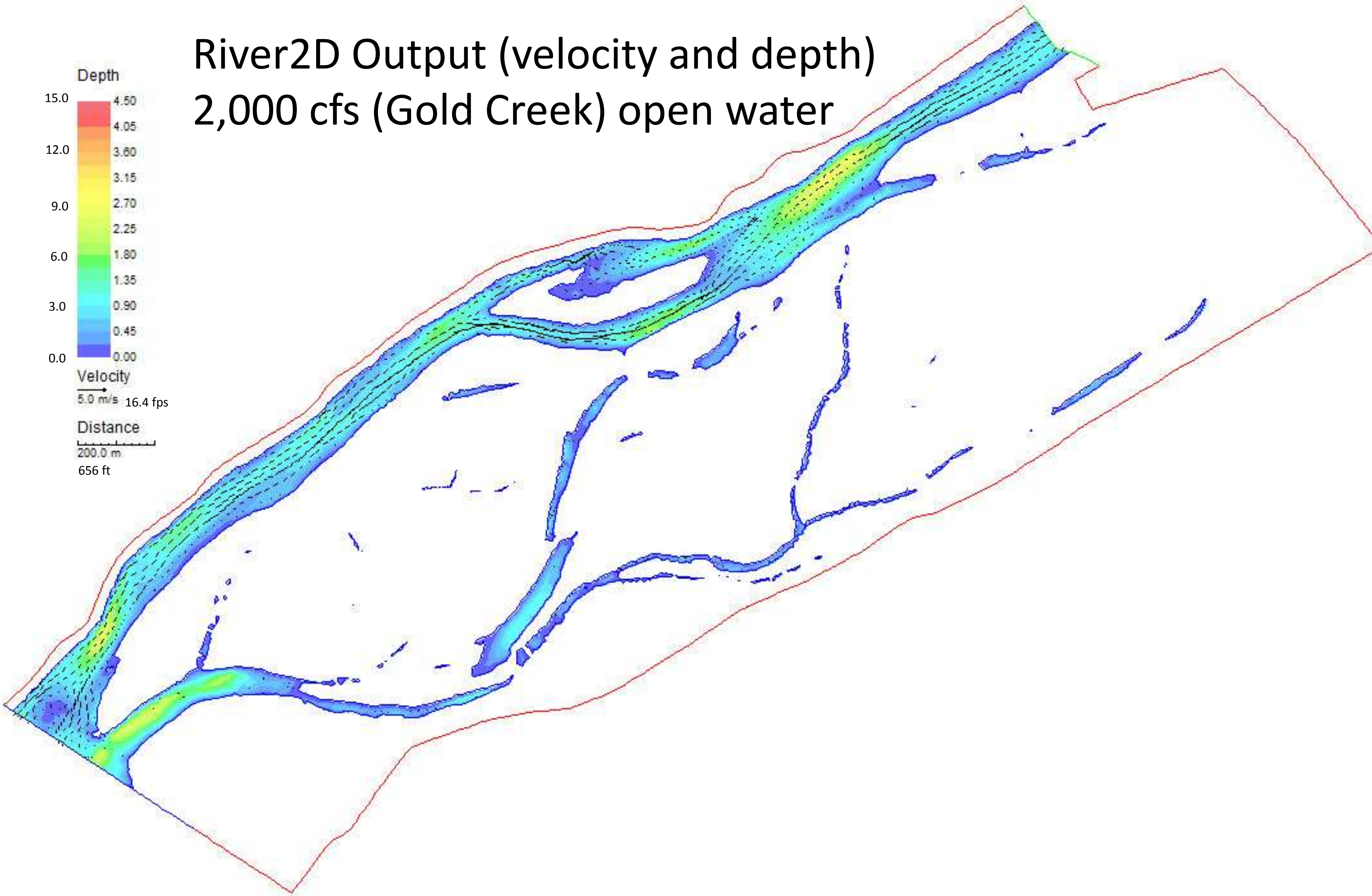
Initial ice covered modeling utilized 1 meter (3.28 ft) of ice in the main channel and major side channel areas



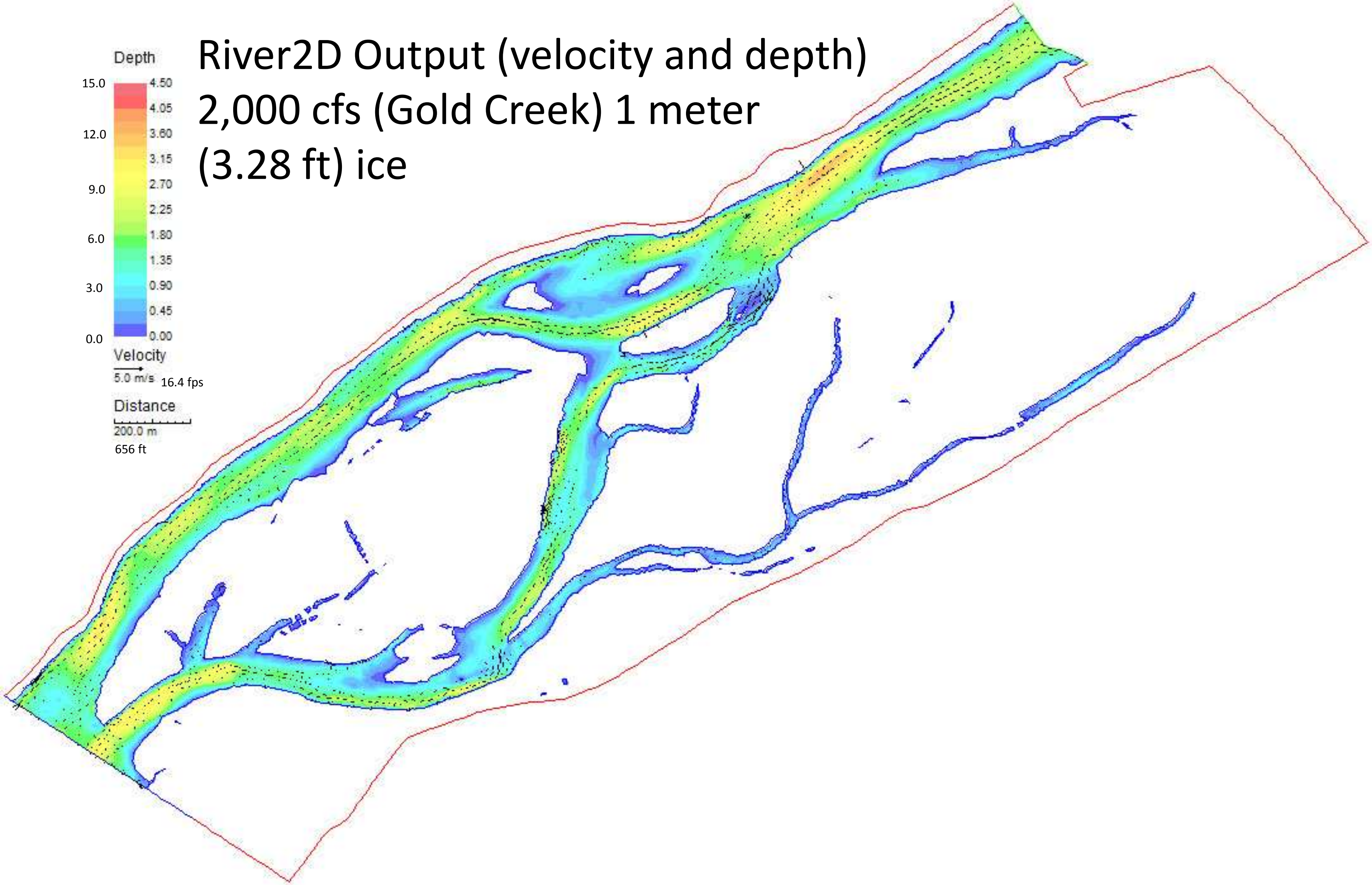
River2D Output (velocity and depth) 6,000 cfs (Gold Creek) 1 meter (3.28 ft) ice



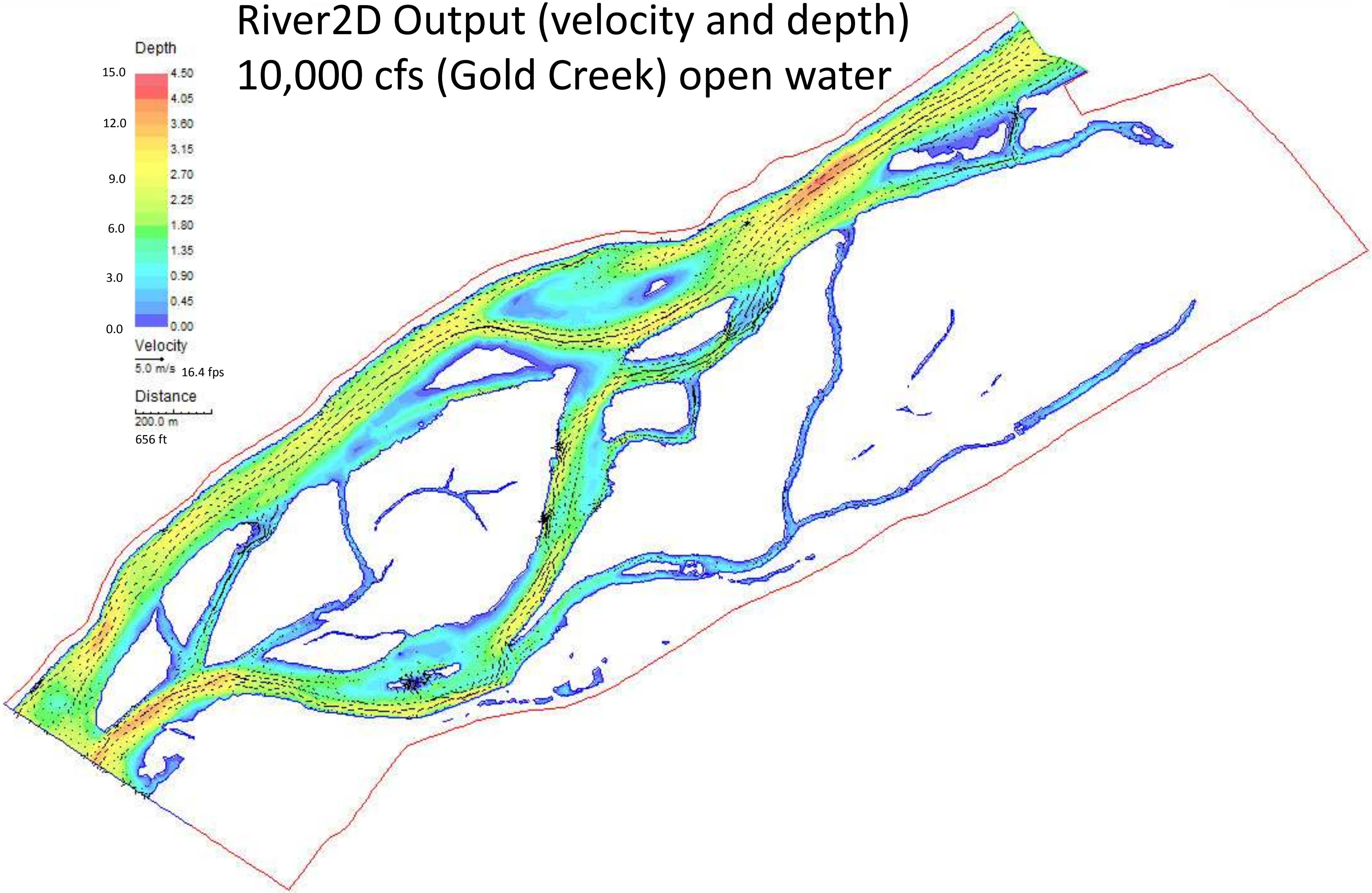
River2D Output (velocity and depth)
2,000 cfs (Gold Creek) open water



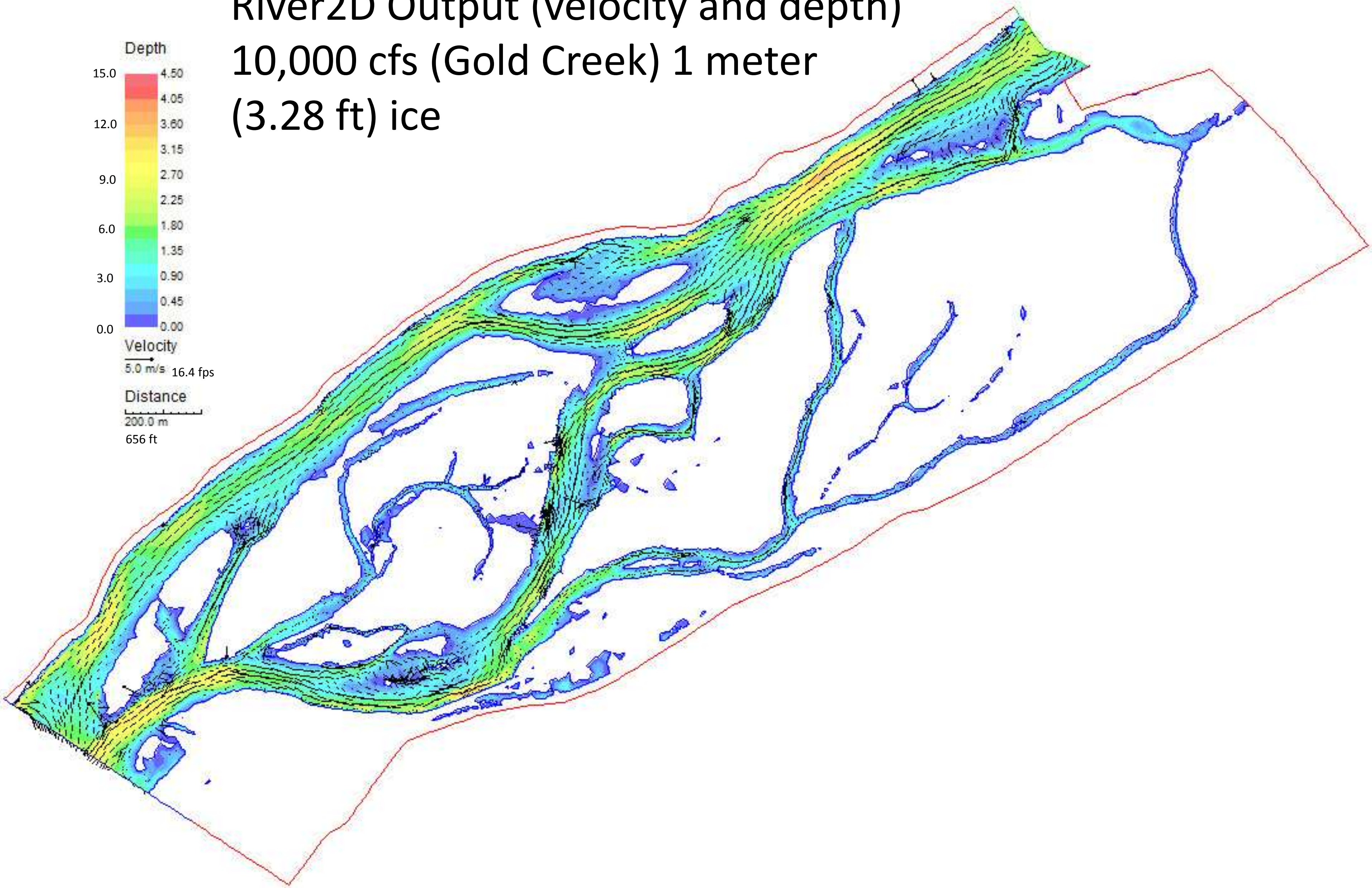
River2D Output (velocity and depth) 2,000 cfs (Gold Creek) 1 meter (3.28 ft) ice



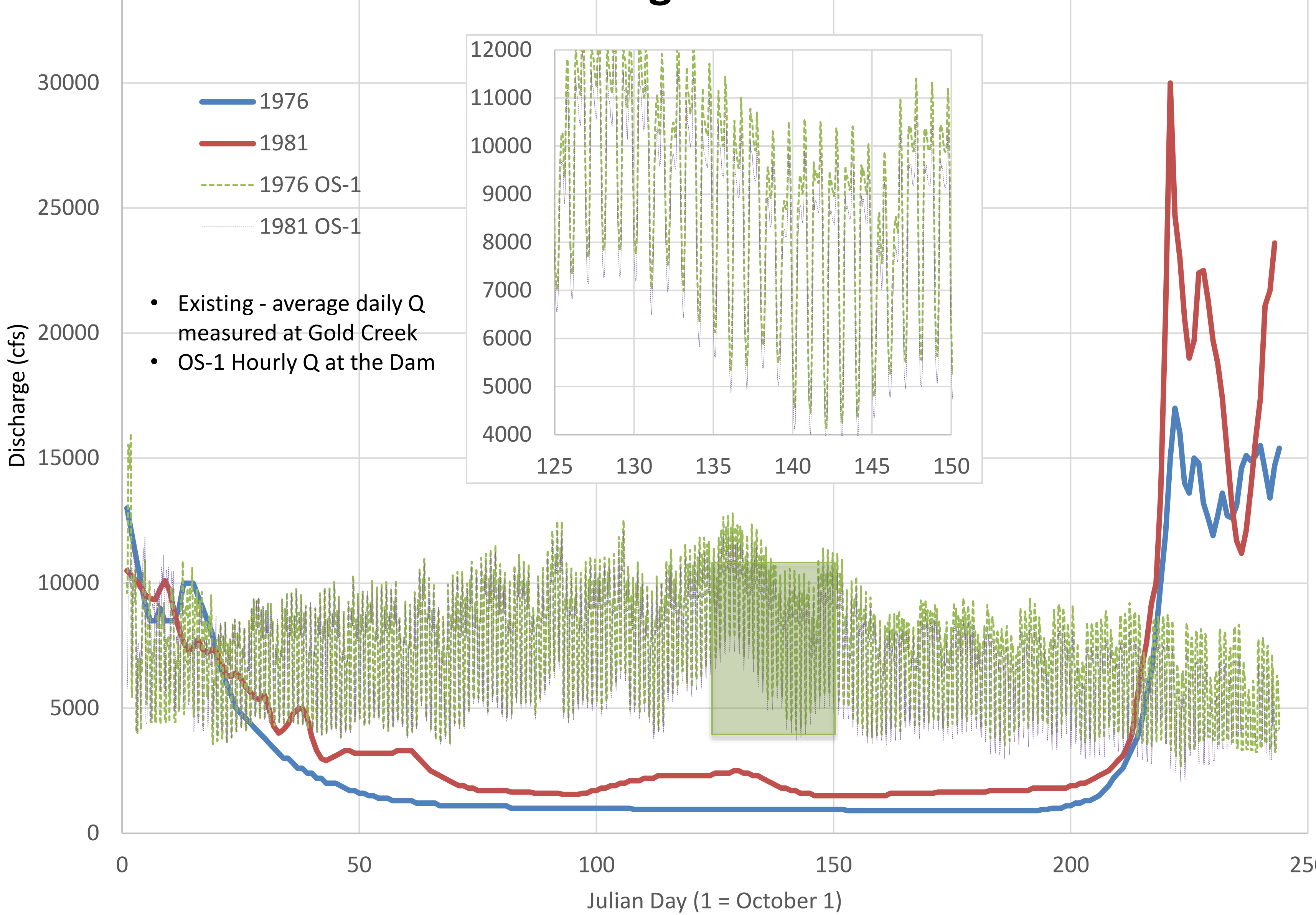
River2D Output (velocity and depth)
10,000 cfs (Gold Creek) open water



River2D Output (velocity and depth) 10,000 cfs (Gold Creek) 1 meter (3.28 ft) ice



Existing vs OS-1b



Potential Project Impacts

- Freeze-up
  - Higher discharge results in higher water levels
  - Warmer dam release delays onset of freeze-up
  - Thicker freeze-up covers (higher Q)
- Mid-Winter
  - Higher discharge results in higher water levels
  - Levels maintained all winter
  - Large fluctuations at upstream edge of ice cover
- Breakup
  - Lower discharge
  - Earlier breakup
  - Thermal vs dynamic
  - Less flooding and damage

Ice Questions and Metrics

- Will ice floodplain vegetation disturbance patterns change with Project operations? Where will it change?
  - Compare existing and with project ice and ice-free zones
  - 1D and 2D ice modeling
  - Ice scars, vegetation damage, historic observations
- Will the ice shearing zones and sediment deposition zones change with project operations?
  - Compare existing shear zones with those likely during project operations
  - 1D and 2D modeling
  - Model areal extent of backwater, velocities, water levels
- How will frequency of ice events change?
  - Ice modeling and dendrochronology of past events

Questions?