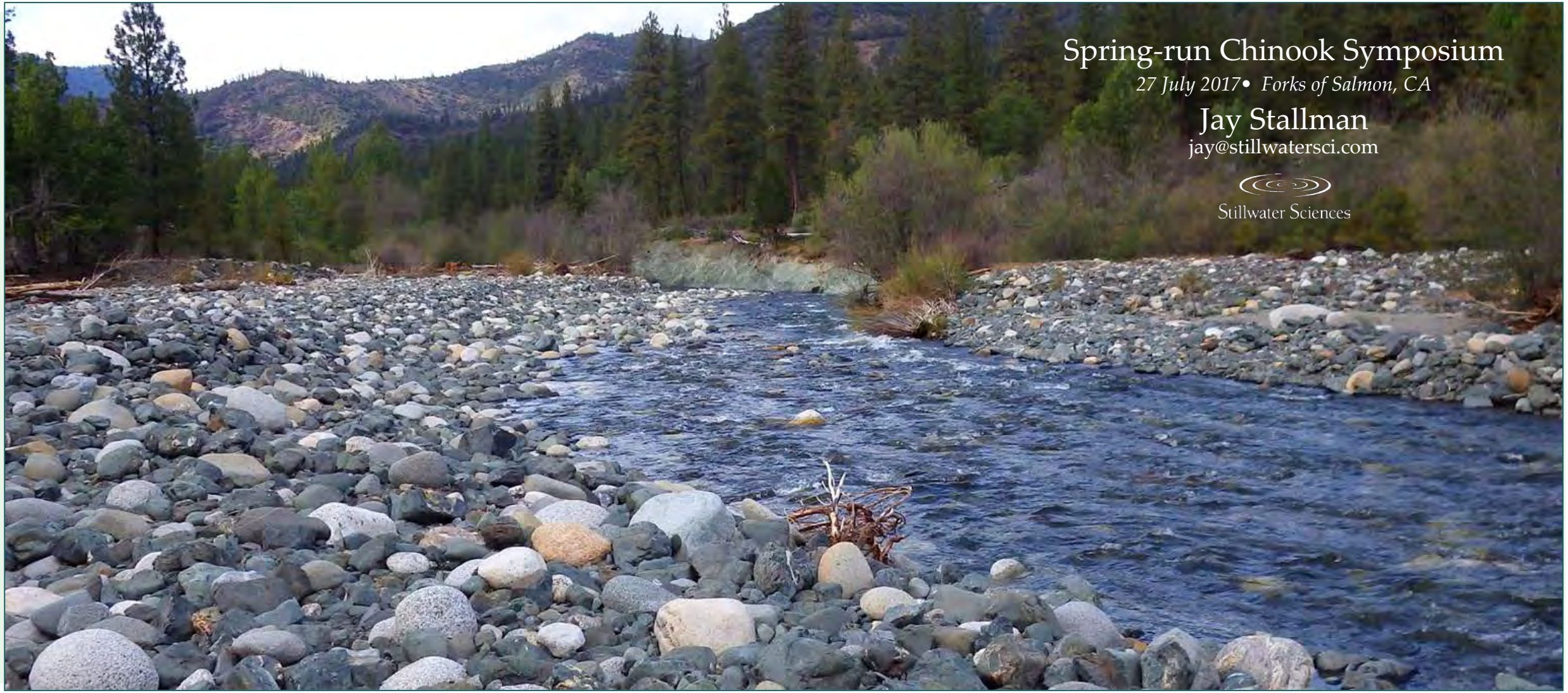
SALMON RIVER FLOODPLAIN & MINE TAILING HABITAT RESTORATION AND ENHANCEMENT



Spring-run Chinook Symposium

27 July 2017• Forks of Salmon, CA

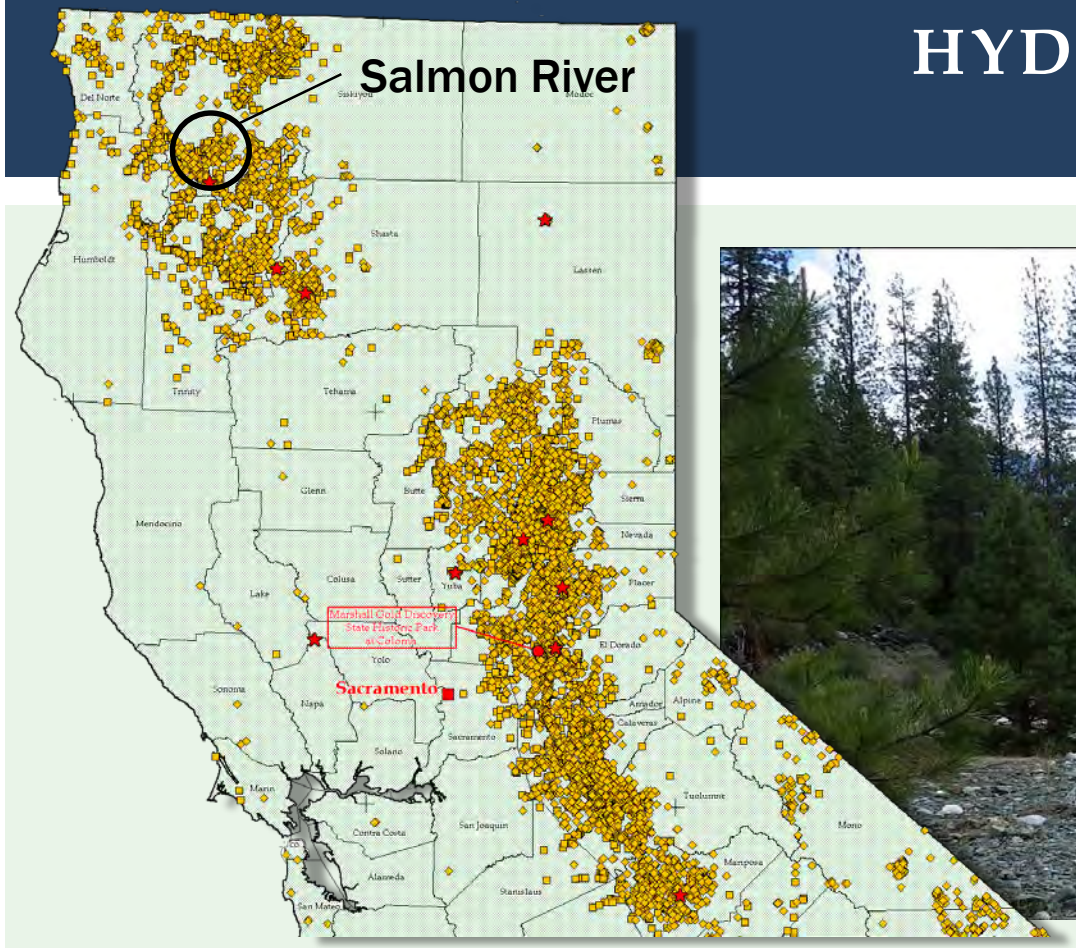
Jay Stallman
jay@stillwatersci.com
Stillwater Sciences

SALMON RIVER

- **Resiliency**
  - High elevation sub-basin within Klamath River
  - Federal ownership and protections
  - Little diversion for consumptive water use
  - Removed from Klamath Basin hatcheries
  - Community support for restoration

- **Vulnerability**
  - Poor off-channel rearing and over-wintering habitat
  - Poor summer rearing habitat
  - Depressed over-summering carrying capacity
  - Poor spawning habitat

HYDRAULIC PLACER MINING LEGACY



- Denudation = degraded riparian conditions, reduced shade cover & increased exposure to solar radiation
- Aggradation = wider & shallower channels, reduced pool depth, reduced complexity, disconnected floodplain and off-channel habitats.
- Coarse sediment inputs = Coarsened bed with reduced mobility, less and lower quality spawning habitat
- Elevated summer water temperatures = limited thermal refugia

SALMON RIVER FLOODPLAIN & MINE TAILING HABITAT RESTORATION AND ENHANCEMENT PLAN

- **SRRC initiated collaborative, science-based planning process in 2014**
- **System-wide approach to strategically restore and enhance stream temperatures, geomorphic functions, and fish habitat.**
- **Overarching goal: Increase long-term salmonid productivity.**
- **Objectives:**
  - Improve riparian functions (e.g, shading, hyporheic exchange)
  - Protect and enhance thermal refugia within summer low flow channel
  - Improve limiting habitat conditions for salmonids
  - Increase resiliency against global warming impacts

SALMON RIVER FLOODPLAIN & MINE TAILING HABITAT RESTORATION AND ENHANCEMENT PLAN

- **Project area includes 55 mi from Nordheimer Creek on Mainstem to wilderness boundaries on North Fork and South Fork.**
  - ➢14 alluvial channel reaches totaling 37 river miles.
  - ➢36 potential enhancement segments totaling 13 miles

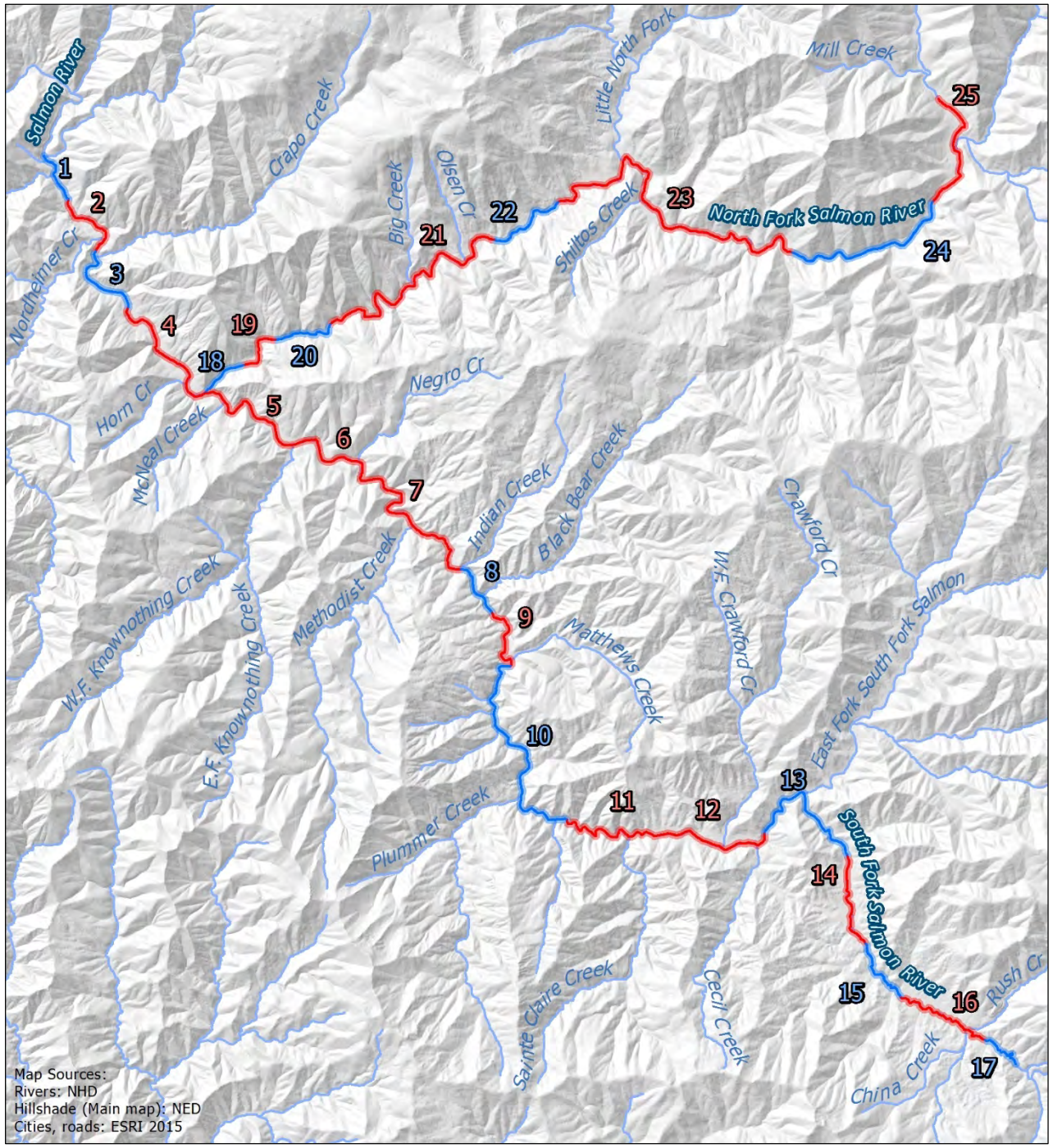
- **Three phases:**
  1. **Develop plan that includes system-wide assessment of opportunities and constraints, identifies and prioritizes suitable sites, and provides conceptual designs for priority sites.**
  2. **Environmental review and permitting.**
  3. **Phased implementation.**

WORK TO DATE

- Technical Advisory Committee formed
- In-Stream Restoration Candidate Action Table
- Riparian vegetation assessment
- LiDAR and TIR data acquisition
- Delineation of alluvial reaches and segments
- Delineation of mine-tailings and related disturbances
- Hydraulic modeling of floodplain inundation
- Analysis of thermal refugia using TIR data
- Off-channel and riparian habitat enhancement design projects

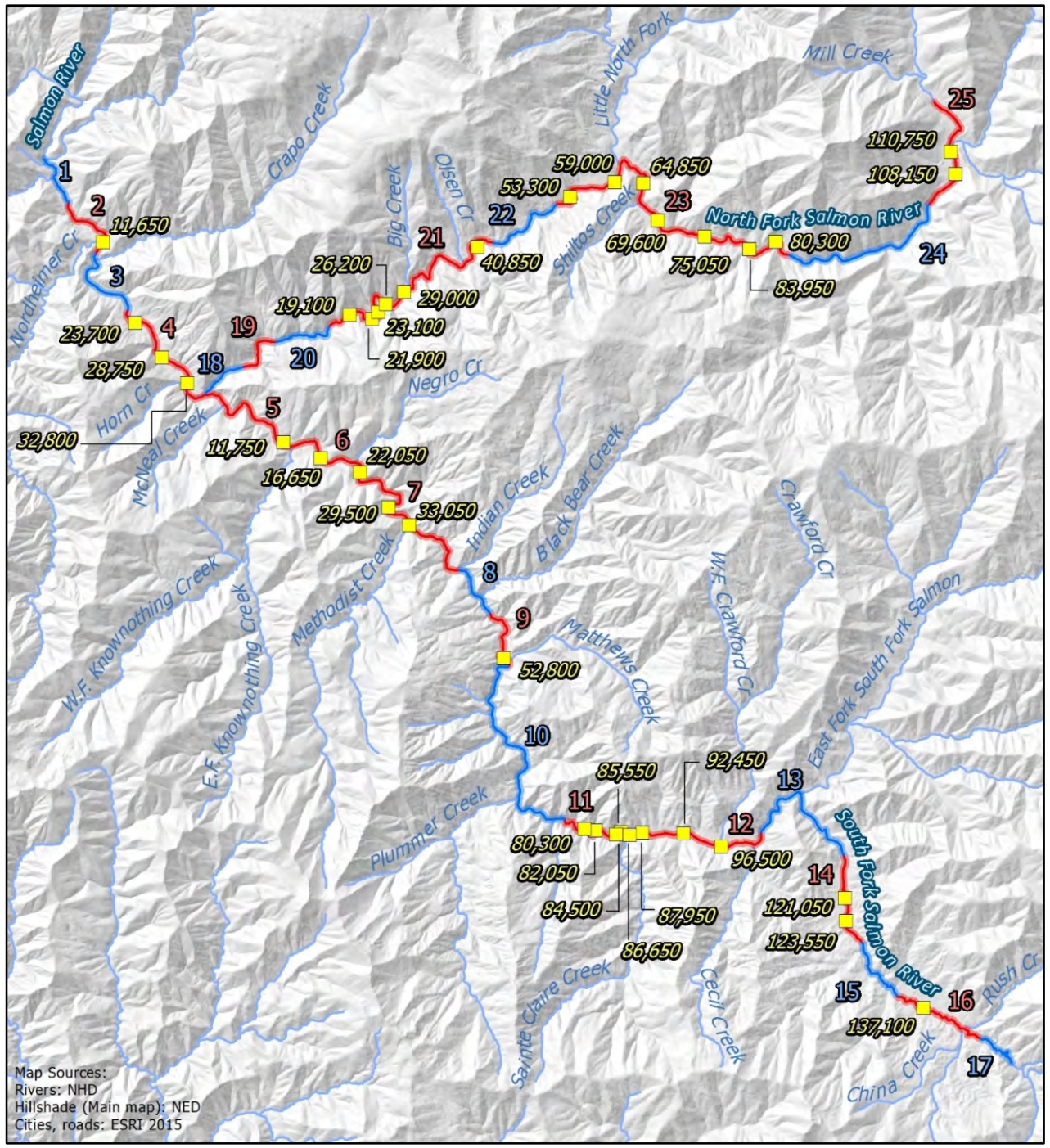
FLOODPLAIN HABITAT RESTORATION AND ENHANCEMENT POTENTIAL

- **Life Histories and Limiting Factors**
- **Disturbance history**
- **Reach morphology**
- **Thermal Landscape**
- **Flow Inundation**
- **Site-scale geomorphology**



REACH-SCALE MORPHOLOGY

- **Valley width/confinement**
- **Bedrock vs alluvial boundaries**
- **Extent of mining disturbance and infrastructure**



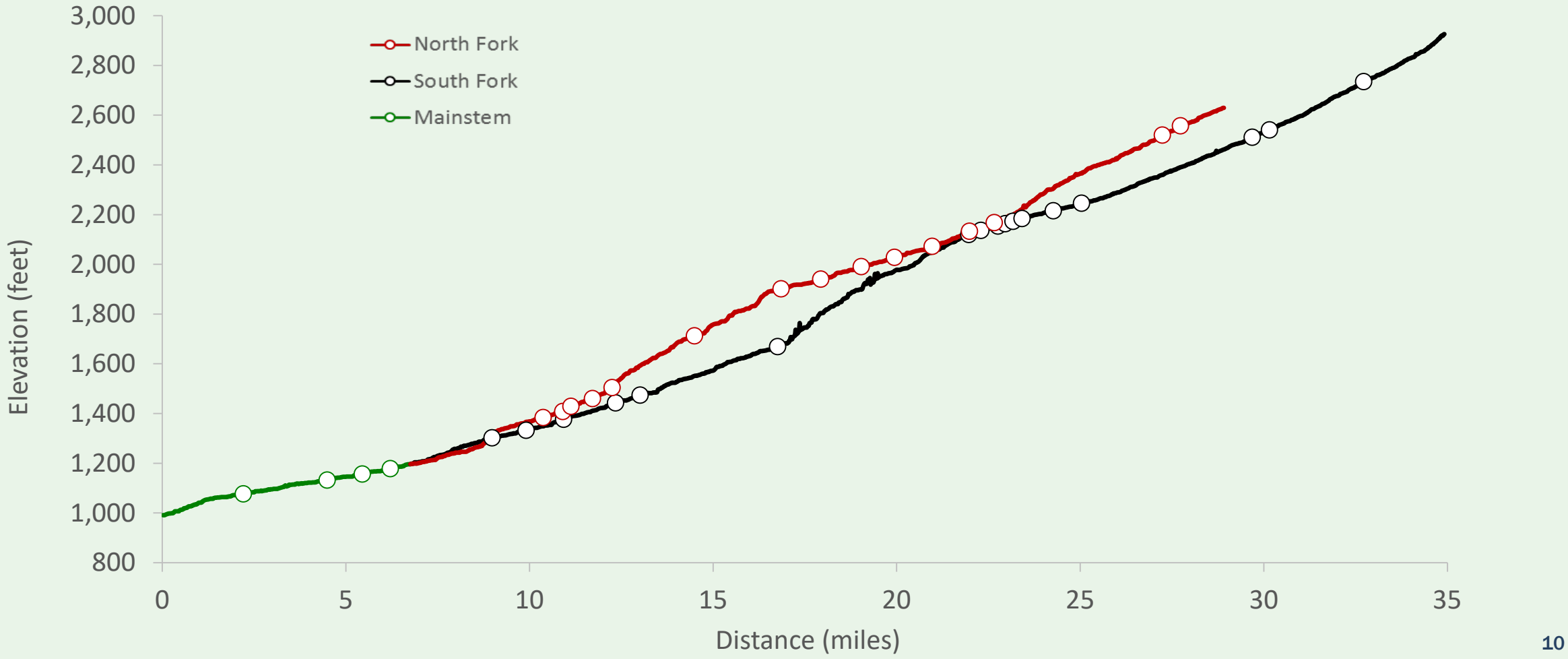
REACH-SCALE MORPHOLOGY

- Valley width/confinement
- Bedrock vs alluvial boundaries
- Extent of mining disturbance and infrastructure

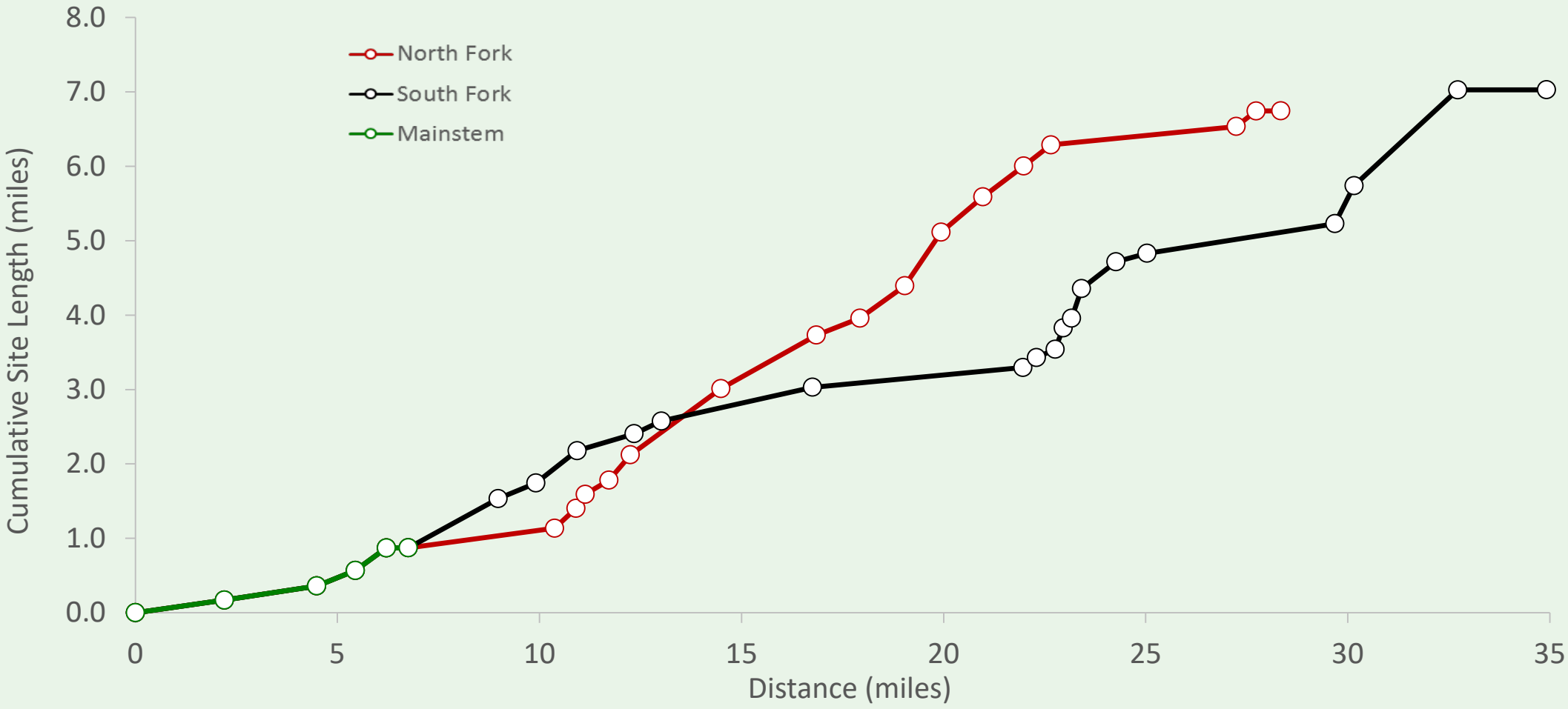
SEGMENT-SCALE FLOODPLAIN ENHANCEMENT POTENTIAL

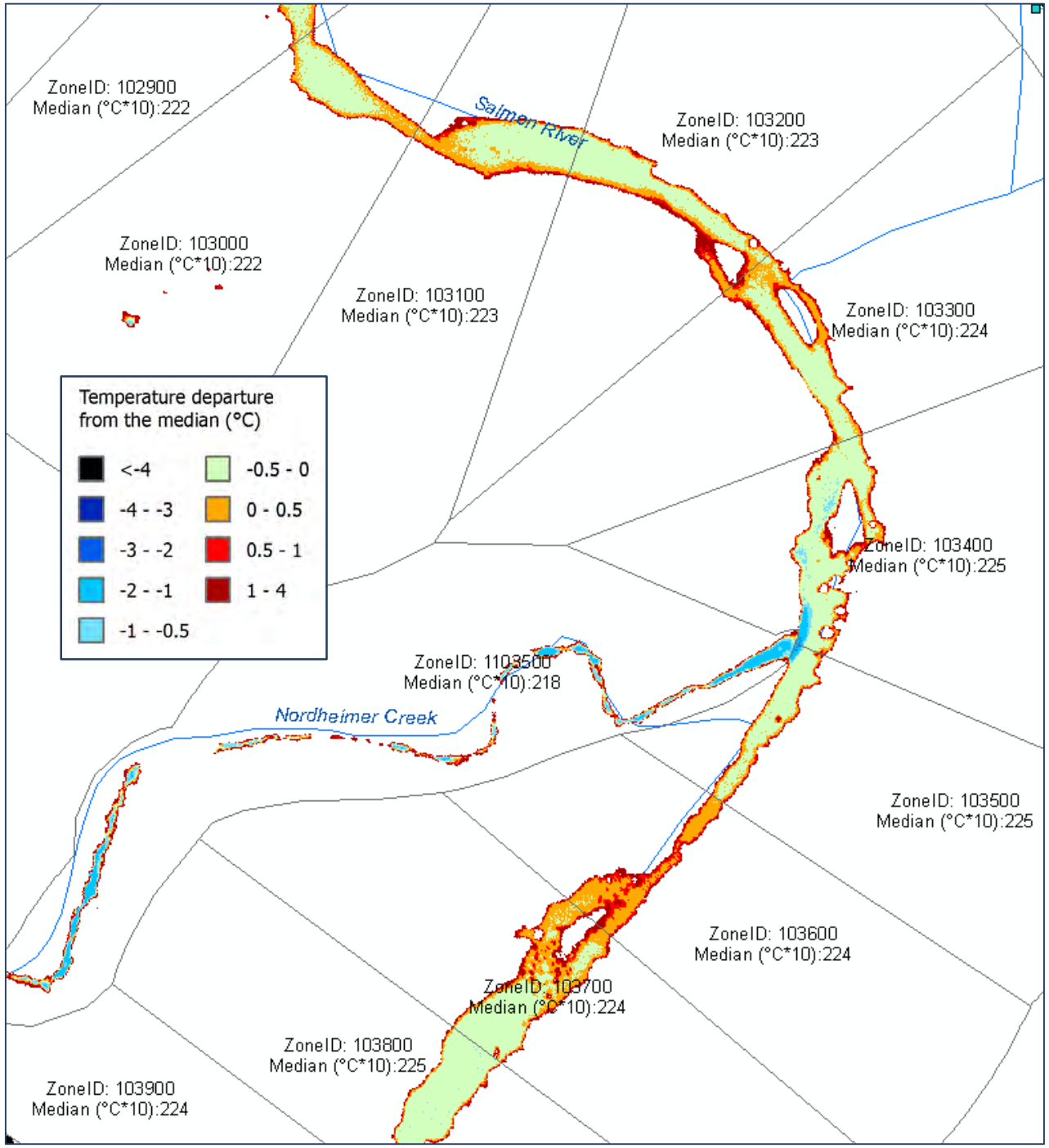
- Channel gradient and confinement
- Alluvial channel features
- Floodplain inundation
- Summer thermal conditions
- Riparian vegetation
- Spawning and rearing habitat
- In-stream restoration priorities identified by Technical Advisory Committee

DISTRIBUTION OF POTENTIAL FLOODPLAIN ENHANCEMENT SEGMENTS



CUMULATIVE LENGTH OF POTENTIAL FLOODPLAIN ENHANCEMENT SEGMENTS



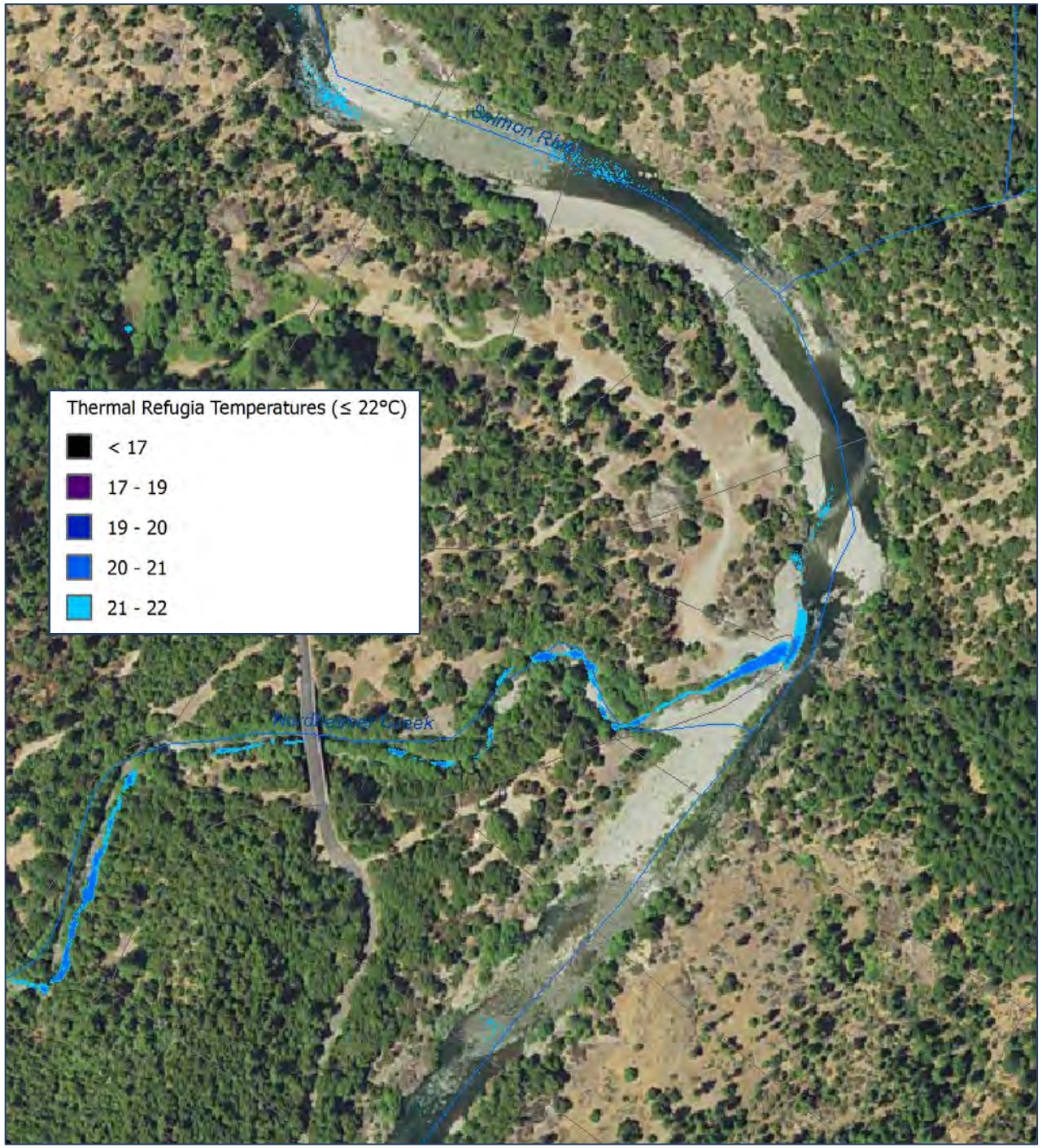


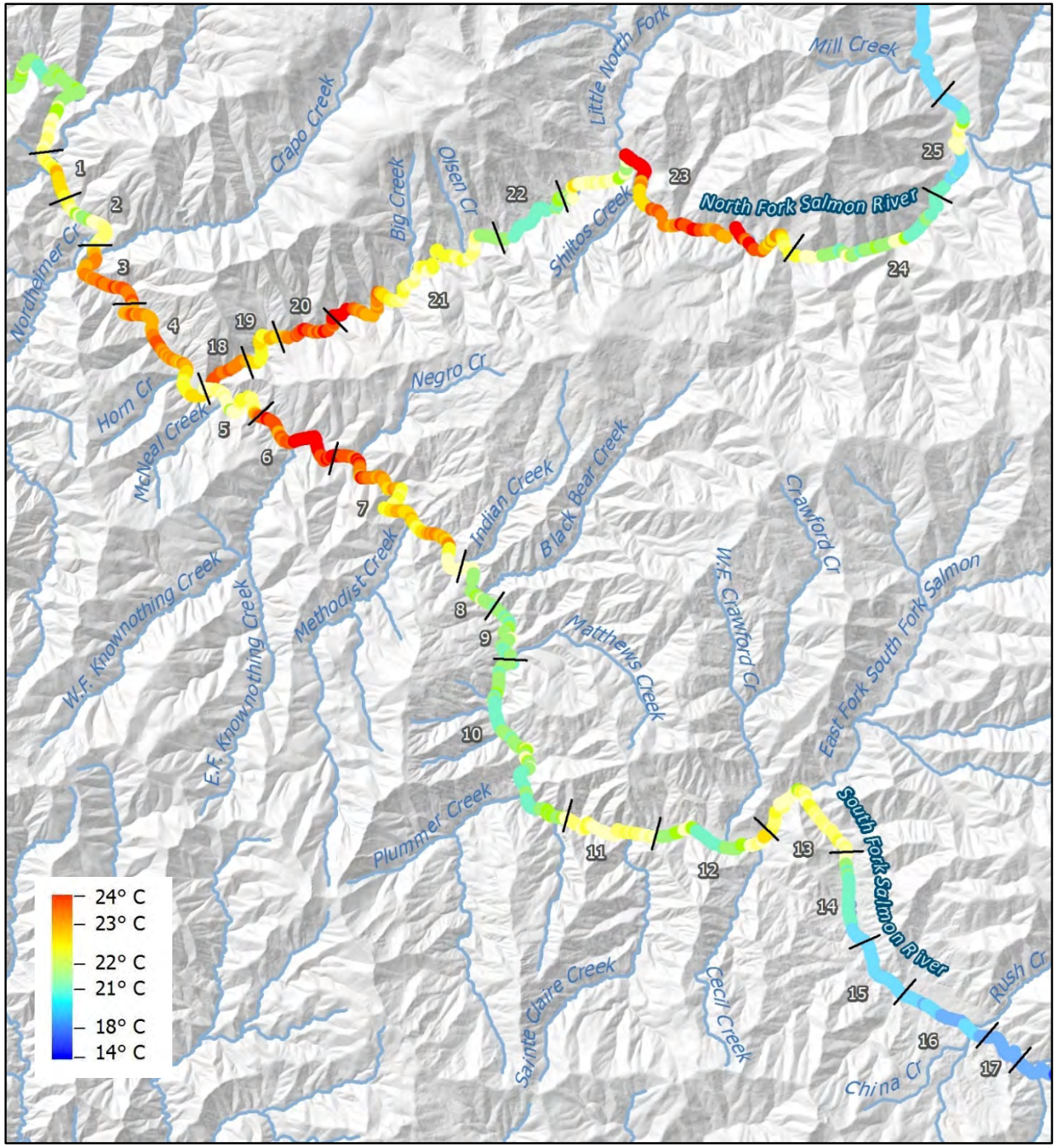
THERMAL LANDSCAPE

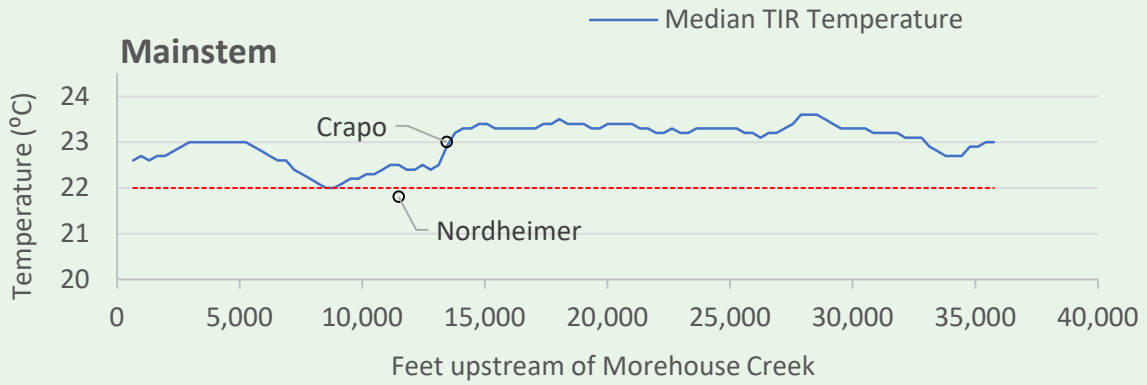
Approach:

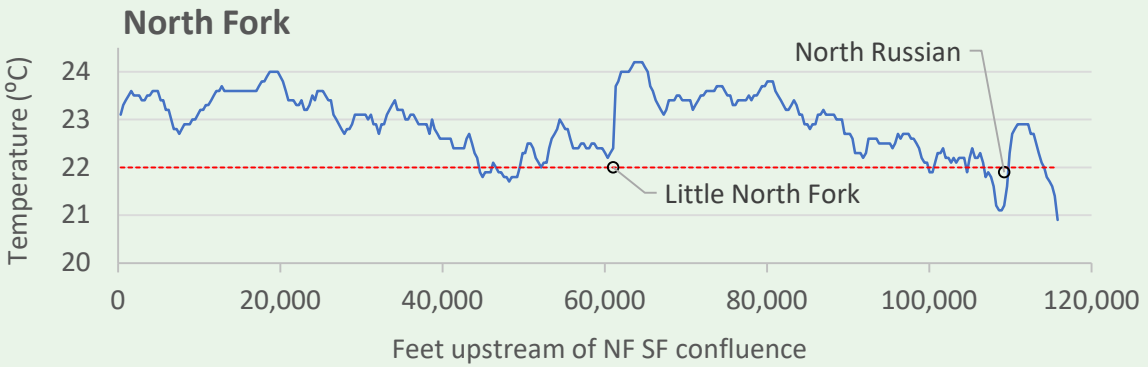
- Airborne thermal infrared (TIR) imagery acquired for 85 mi in July, 2009
- 25°C defines wetted channel
- 100 meter sampling zones
- Moving median temperatures over 500 meter channel length
- Temperature departure calculated by subtracting median zone temperature from observed TIR temperature
- Temperatures within thermal refugia identified based on 22°C threshold.

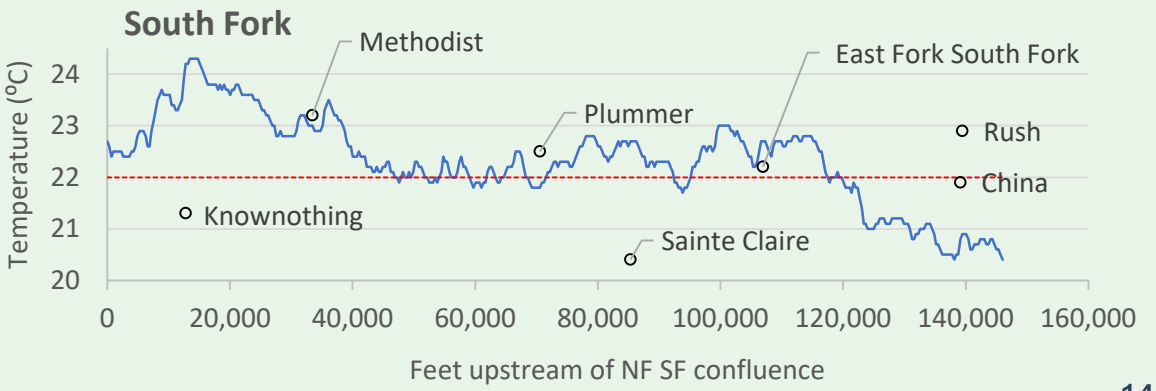
THERMAL LANDSCAPE



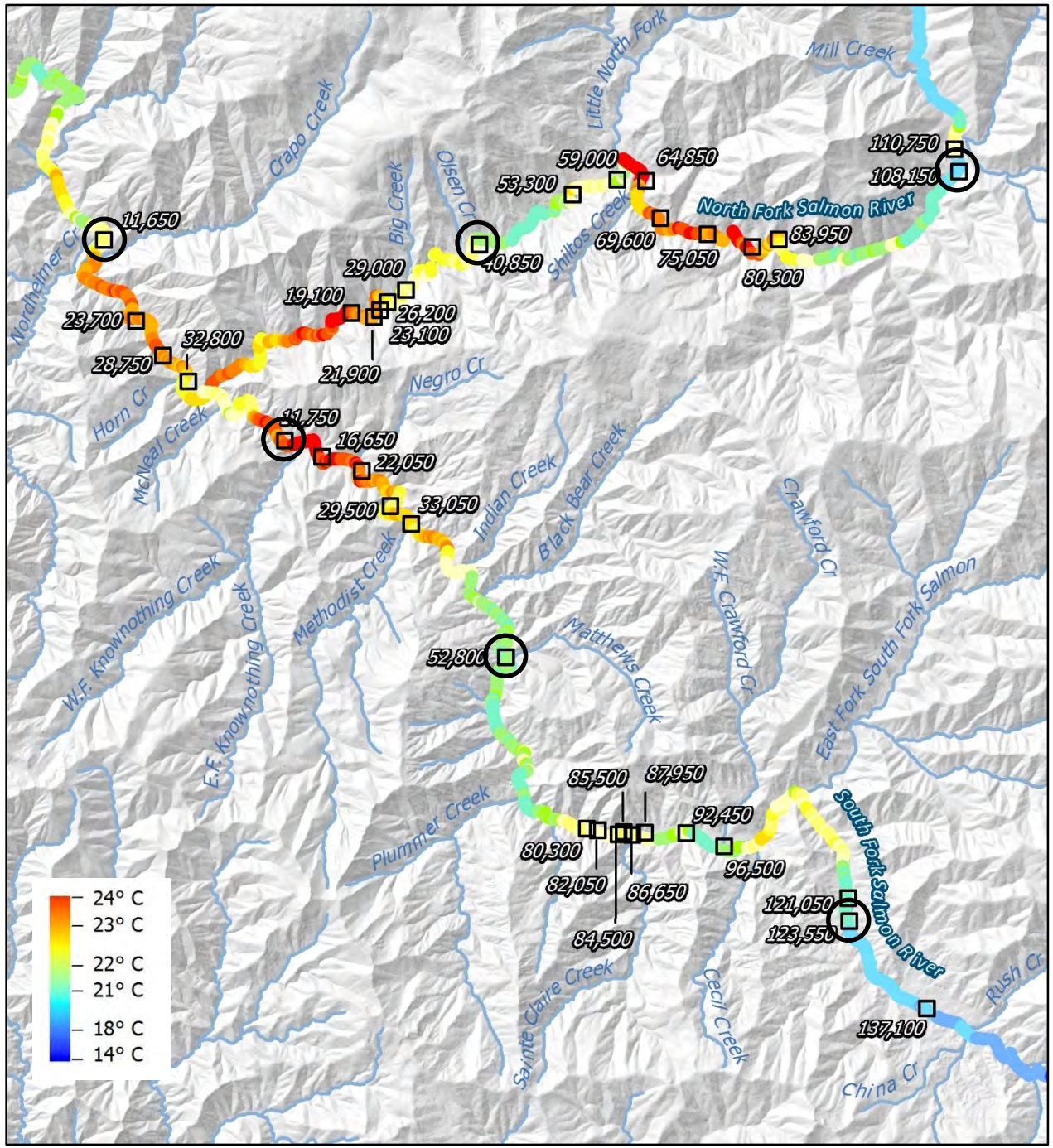

Mill Creek
Little North Fork
Crapo Creek
Big Creek
Olsen Cr
Shiltos Creek
North Fork Salmon River
Nordheimer Cr
Horn Cr
McNeal Creek
Negro Cr
Indian Creek
Black Bear Creek
Crawford Cr
W.F. Crawford Cr
East Fork South Fork Salmon
W.F. Knownothing Creek
E.F. Knownothing Creek
Methodist Creek
Matthews Creek
Plummer Creek
South Fork Salmon River
Sainte Claire Creek
Cecil Creek
Rush Cr
China Cr
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
24° C
23° C
22° C
21° C
18° C
14° C

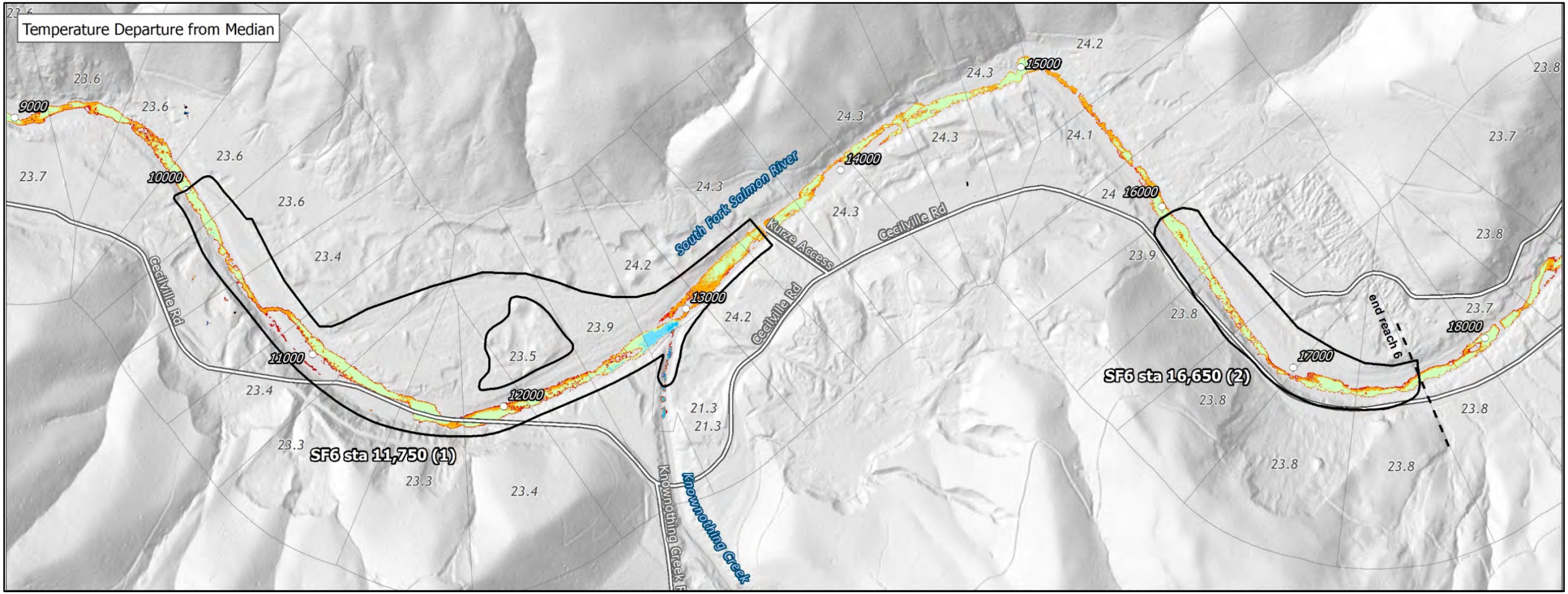

Median TIR Temperature
Mainstem
Temperature (°C)
24
23
22
21
20
Crapo
Nordheimer
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
Feet upstream of Morehouse Creek


North Fork
Temperature (°C)
24
23
22
21
20
North Russian
Little North Fork
0
20,000
40,000
60,000
80,000
100,000
120,000
Feet upstream of NF SF confluence


South Fork
Temperature (°C)
24
23
22
21
20
Methodist
East Fork South Fork
Plummer
Rush
China
Knownothing
Sainte Claire
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
160,000
Feet upstream of NF SF confluence

EXAMPLES


Mill Creek
Little North Fork
Crapo Creek
Big Creek
Olsen Cr
Shitos Creek
North Fork Salmon River
Northheimer Cr
Horn Cr
McNeal Creek
Negro Cr
Indian Creek
Black Bear Creek
Methodist Creek
W.F. Knownothing Creek
E.F. Knownothing Creek
Matthews Creek
W.F. Crawford Cr
Crawford Cr
East Fork South Fork Salmon
Plummer Creek
South Fork Salmon River
Sainte Claire Creek
Cecil Creek
Rush Cr
China Cr
11,650
23,700
28,750
32,800
19,100
29,000
26,200
23,100
21,900
40,850
53,300
59,000
64,850
69,600
75,050
80,300
83,950
110,750
108,150
11,750
16,650
22,050
29,500
33,050
52,800
85,500
87,950
80,300
82,050
84,500
86,650
92,450
96,500
121,050
123,550
137,100
24° C
23° C
22° C
21° C
18° C
14° C



Temperature departure from the median (°C)

- <-4
- -4 - -3
- -3 - -2
- -2 - -1
- -1 - -0.5
- -0.5 - 0
- 0 - 0.5
- 0.5 - 1
- 1 - 4

0 250 500 1,000 Feet

0 50 100 200 Meters

1:6,500 1 in = 542 feet


Thermal Refugia Temperatures
0 250 500 1,000
Feet
0 50 100 200
Meters
1:6,500
1 in = 542 feet
Thermal Refugia Temperatures (≤ 22°C)
< 17
17 - 19
19 - 20
20 - 21
21 - 22

Temperature departure from the median (°C)

- <-4
- -4 - -3
- -3 - -2
- -2 - -1
- -1 - -0.5
- -0.5 - 0
- 0 - 0.5
- 0.5 - 1
- 1 - 4

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Thermal Refugia Temperatures (≤ 22°C)

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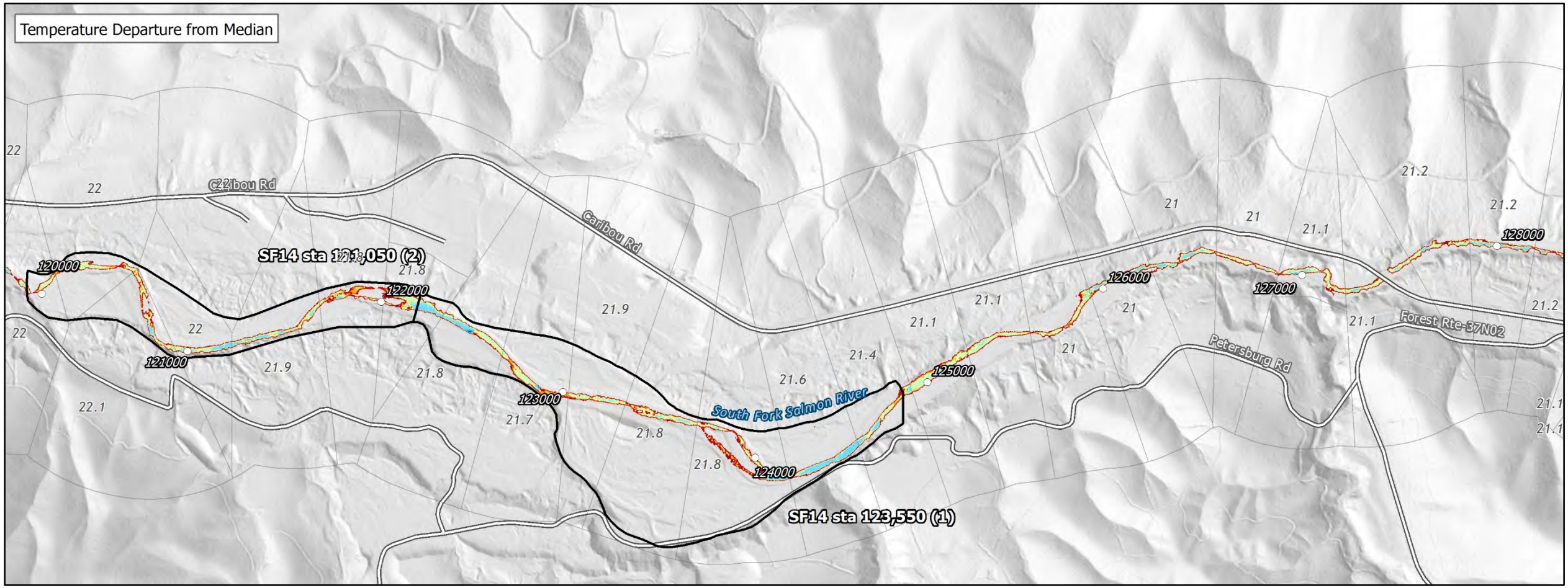

Temperature Departure from Median
Caribou Rd
Caribou Rd
SF14 sta 121,050 (2)
SF14 sta 123,550 (1)
South Fork Salmon River
Petersburg Rd
Forest Rte-37N02
120000
121000
122000
123000
124000
125000
126000
127000
128000
22
22.1
21.9
21.8
21.7
21.6
21.4
21.2
21.1
21
Temperature departure
from the median (°C)
<-4
-4 - -3
-3 - -2
-2 - -1
-1 - -0.5
-0.5 - 0
0 - 0.5
0.5 - 1
1 - 4
0 250 500 1,000 Feet
0 50 100 200 Meters
1:6,500
1 in = 542 feet

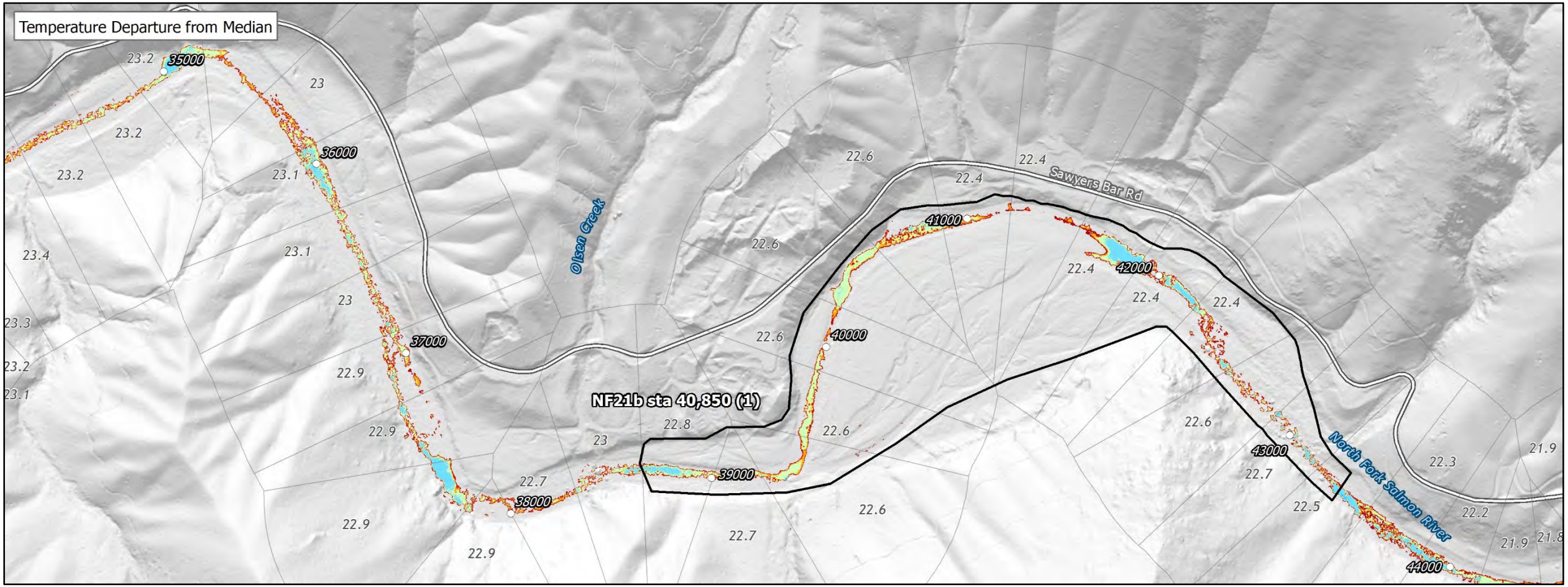
0 250 500 1,000 Feet

0 50 100 200 Meters

1:6,500 1 in = 542 feet

Thermal Refugia Temperatures (≤ 22°C)

- < 17
- 17 - 19
- 19 - 20
- 20 - 21
- 21 - 22



Temperature departure from the median (°C)

- <-4
- -4 - -3
- -3 - -2
- -2 - -1
- -1 - -0.5
- -0.5 - 0
- 0 - 0.5
- 0.5 - 1
- 1 - 4

0 250 500 1,000 Feet

0 50 100 200 Meters

1:6,500 1 in = 542 feet

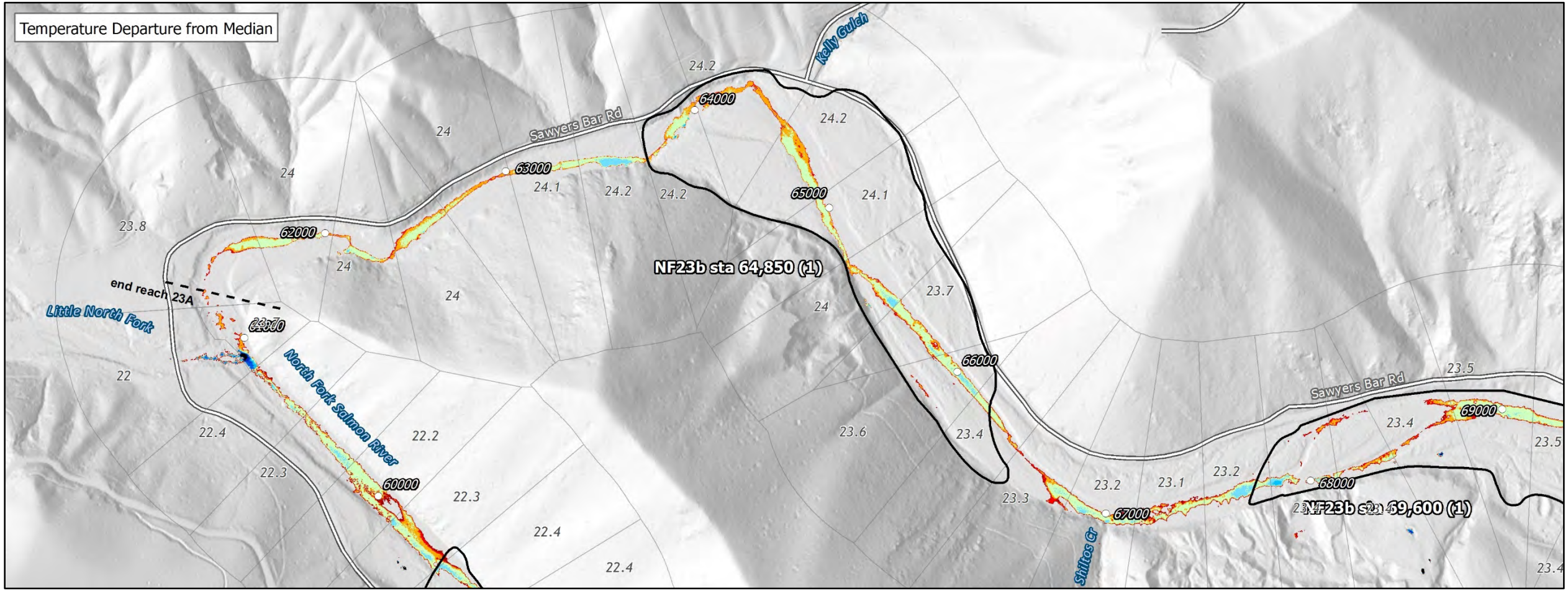
0 250 500 1,000 Feet

0 50 100 200 Meters

1:6,500 1 in = 542 feet

Thermal Refugia Temperatures (≤ 22°C)

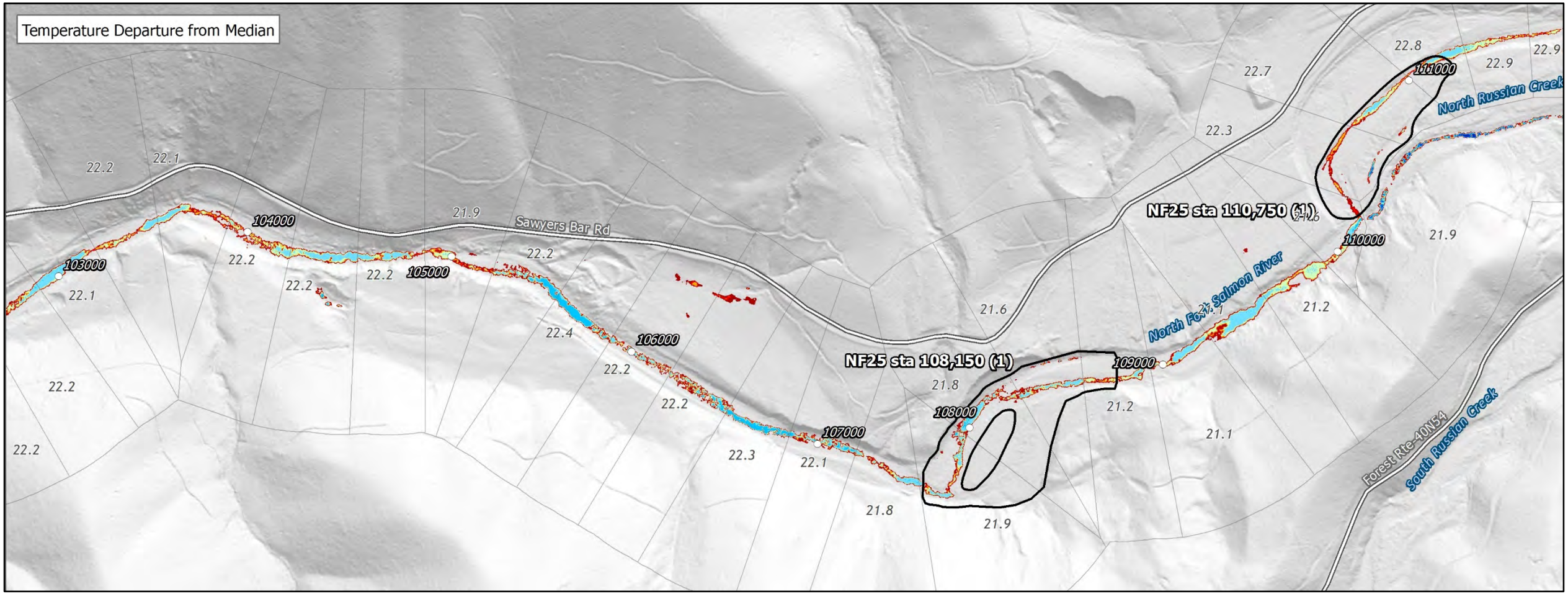
- < 17
- 17 - 19
- 19 - 20
- 20 - 21
- 21 - 22



Temperature departure from the median (°C)

- <-4
- -4 - -3
- -3 - -2
- -2 - -1
- -1 - -0.5
- -0.5 - 0
- 0 - 0.5
- 0.5 - 1
- 1 - 4


Thermal Refugia Temperatures
Thermal Refugia Temperatures (≤ 22°C)
< 17
17 - 19
19 - 20
20 - 21
21 - 22
0 250 500 1,000
Feet
0 50 100 200
Meters
1:6,500
1 in = 542 feet


Temperature Departure from Median
Sawyers Bar Rd
North Russian Creek
North Fork Salmon River
South Russian Creek
Forest Rte-40N54
NF25 sta 110,750 (1)
NF25 sta 108,150 (1)
103000
104000
105000
106000
107000
108000
109000
110000
111000
22.8
22.9
22.7
22.3
22.2
22.1
21.9
21.6
22.4
21.8
22.3
21.2
21.1
0
250
500
1,000
Feet
0
50
100
200
Meters
1:6,500
1 in = 542 feet
Temperature departure from the median (°C)
<-4
-4 - -3
-3 - -2
-2 - -1
-1 - -0.5
-0.5 - 0
0 - 0.5
0.5 - 1
1 - 4

Thermal Refugia Temperatures (≤ 22°C)

- < 17
- 17 - 19
- 19 - 20
- 20 - 21
- 21 - 22

0 250 500 1,000 Feet

0 50 100 200 Meters

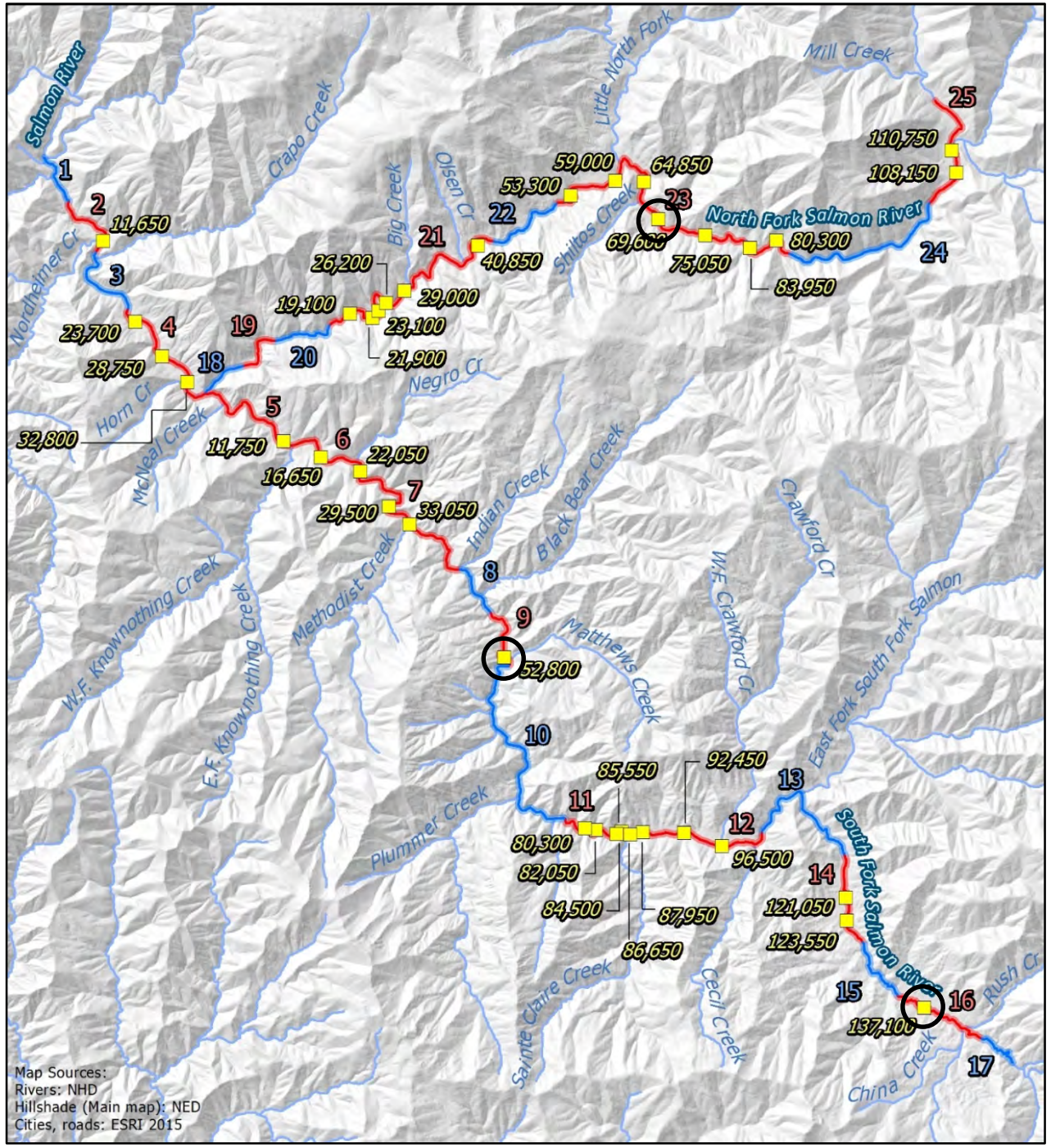
1:6,500 1 in = 542 feet

FLOW INUNDATION

Approach:

- Hydrologic Engineering Center's River Analysis System 5.0 (2D)
- 35 mi of river channel
- Topographic source: 2014 LiDAR DEM
- Grid Resolution:
  - Center spacing 10 ft X 10 ft
  - Refined by adding resolution and strategic cell center orientation
- Simulated Flows:
  - 20% exceedance to 100-year peak flow
  - Daily flow duration and peak flow magnitudes (LPIII) scaled by drainage area using Salmon River at Somes Bar gage (USGS Station No. 11522500; 751 mi^2)

EXAMPLES


Salmon River
Crapo Creek
Little North Fork
Mill Creek
Big Creek
Olsen Cr
Nordheimer Cr
Shitkos Creek
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McNeal Creek
Negro Cr
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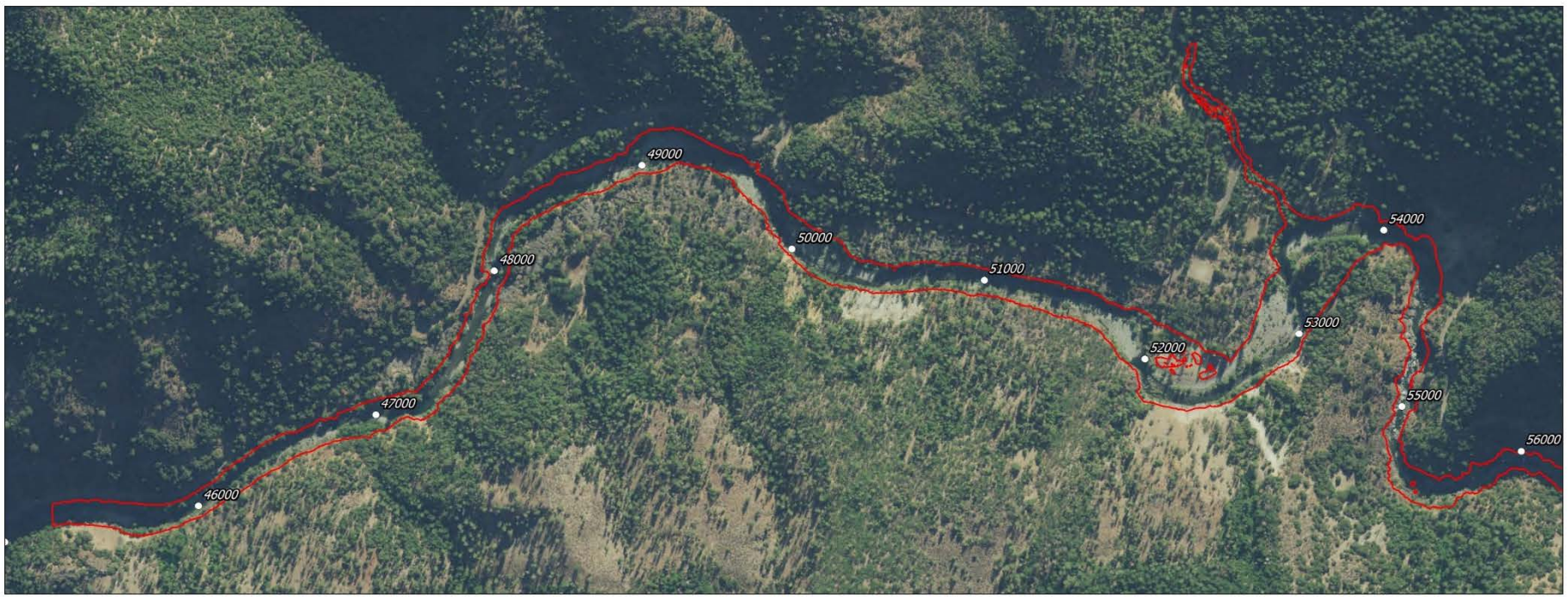
South Fork Salmon River
Rush Cr
China Creek
1
2
11,650
3
23,700
4
28,750
18
19
20
26,200
19,100
21
22
40,850
29,000
23,100
21,900
59,000
53,300
64,850
23
69,600
75,050
80,300
83,950
24
25
110,750
108,150
32,800
5
11,750
6
16,650
22,050
7
29,500
33,050
8
9
52,800
10
11
80,300
82,050
84,500
85,550
87,950
86,650
92,450
12
96,500
13
14
121,050
123,550
15
16
137,100
17
Map Sources:
Rivers: NHD
Hillshade (Main map): NED
Cities, roads: ESRI 2015



Salmon River Floodplain Habitat Enhancement and Mine Tailing Remediation Feasibility Study

Reach 9 (South Fork)

DATA SOURCES
LiDAR: Quantum Spatial, 2014
Roads, cities, streams: ESRI 2015
Imagery: NAIP 2016

MAP PROJECTION
NAD_1983_HARN_StatePlane
California_I_FIPS_0401_Feet

Stillwater Sciences

LEGEND

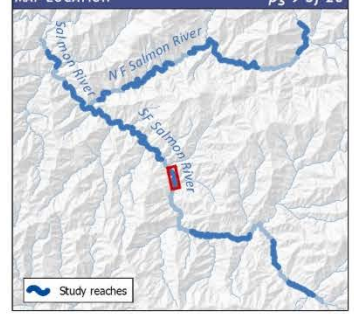
- Potential floodplain enhancement segment
  - MS2 sta 11,650 (1)
  - fork – reach – segment midpoint – suitability rating
- Potential terrace revegetation sites with mine tailings
- Existing and potential off-channel ponds with potential for channel connection
- 100 year floodplain
- Reach break
- 1000-ft stationing

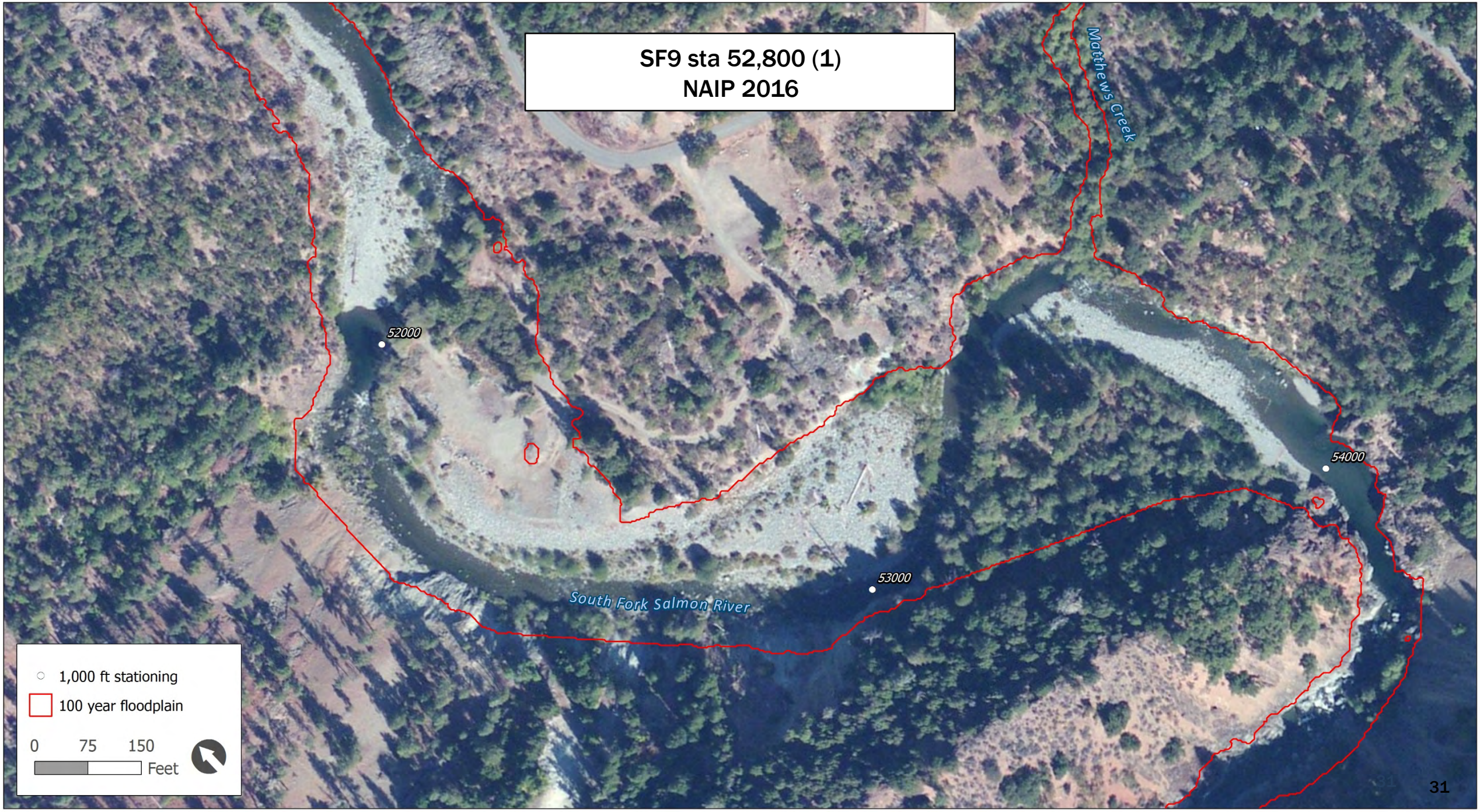
Modeled Inundation

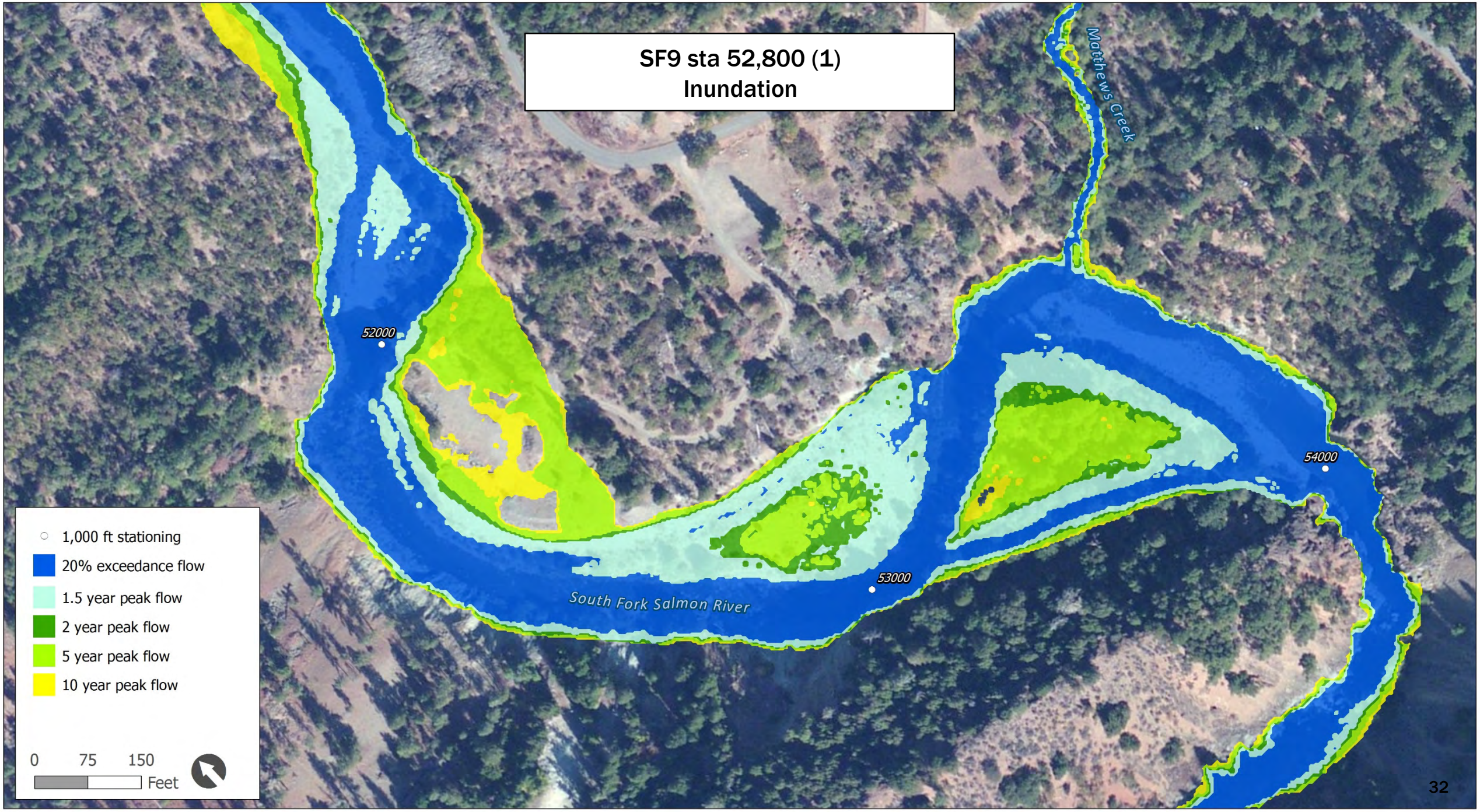
- 20% exceedance flow
- 1/2 of the 1.5 year peak flow
- 1.5 year peak flow
- 2 year peak flow
- 5 year peak flow
- 10 year peak flow
- 25 year peak flow
- 50 year peak flow
- 100 year peak flow

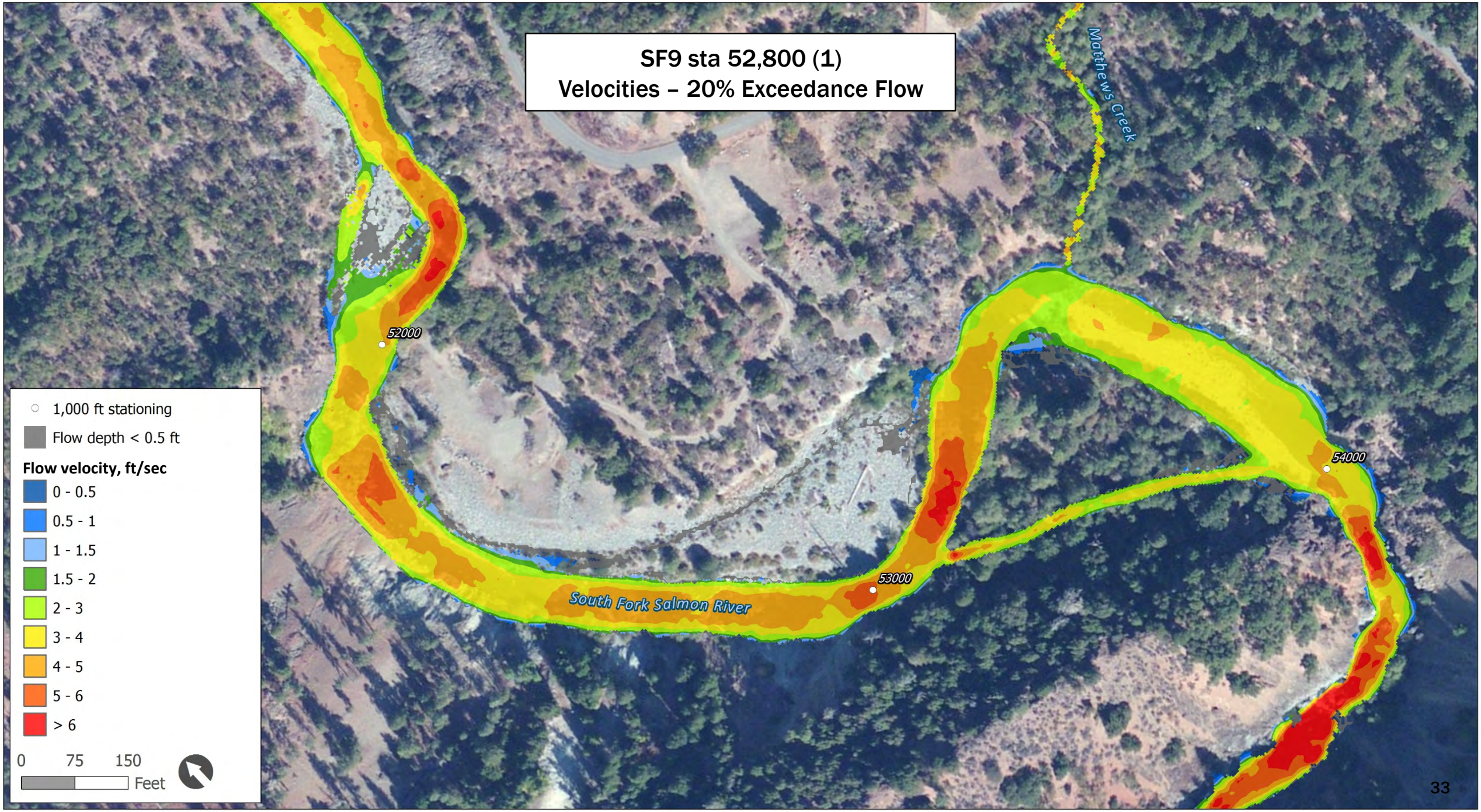
0 250 500 1,000 Feet
0 50 100 200 Meters
1:6,500 1 in = 542 feet

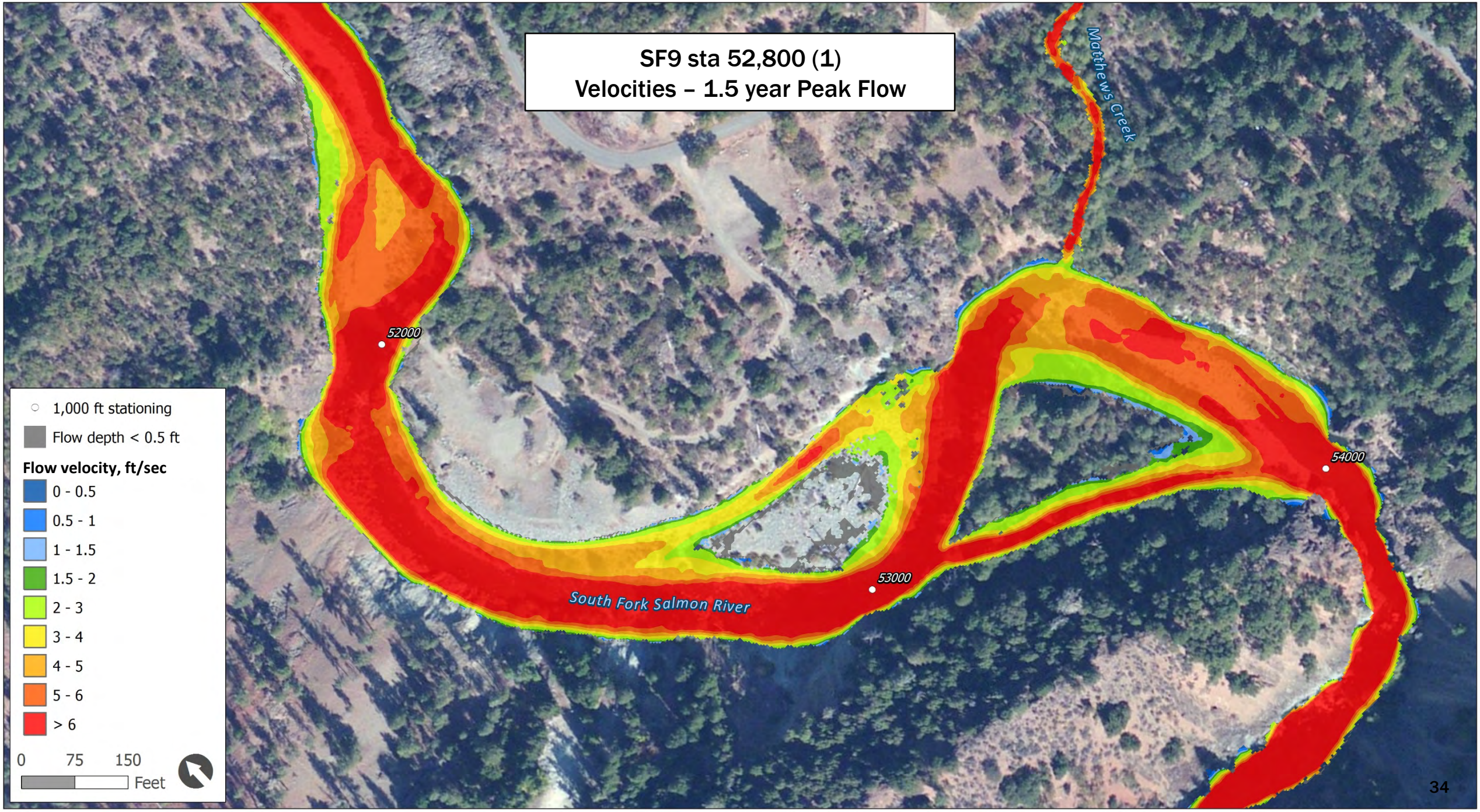
MAP LOCATION *pg 9 of 26*

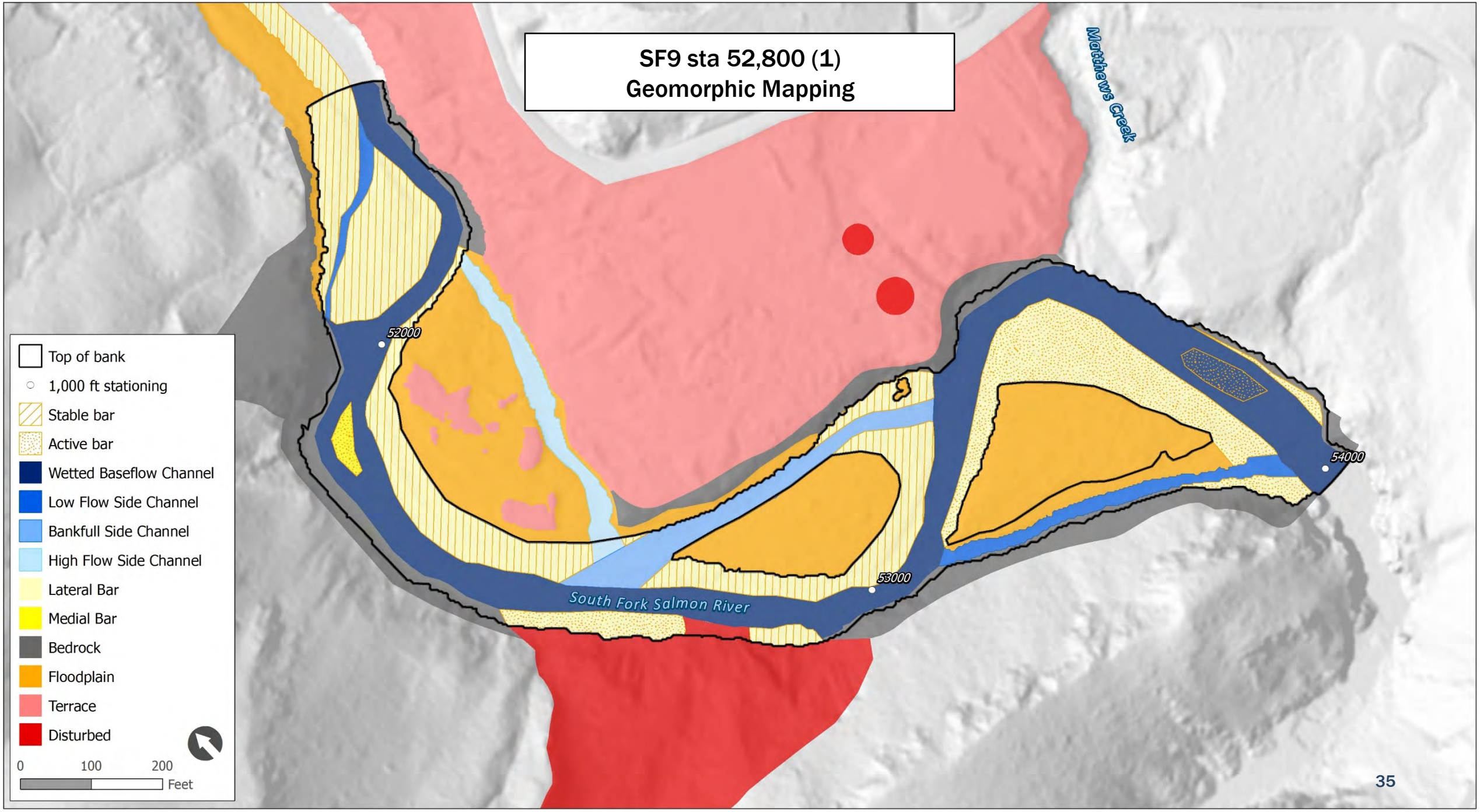


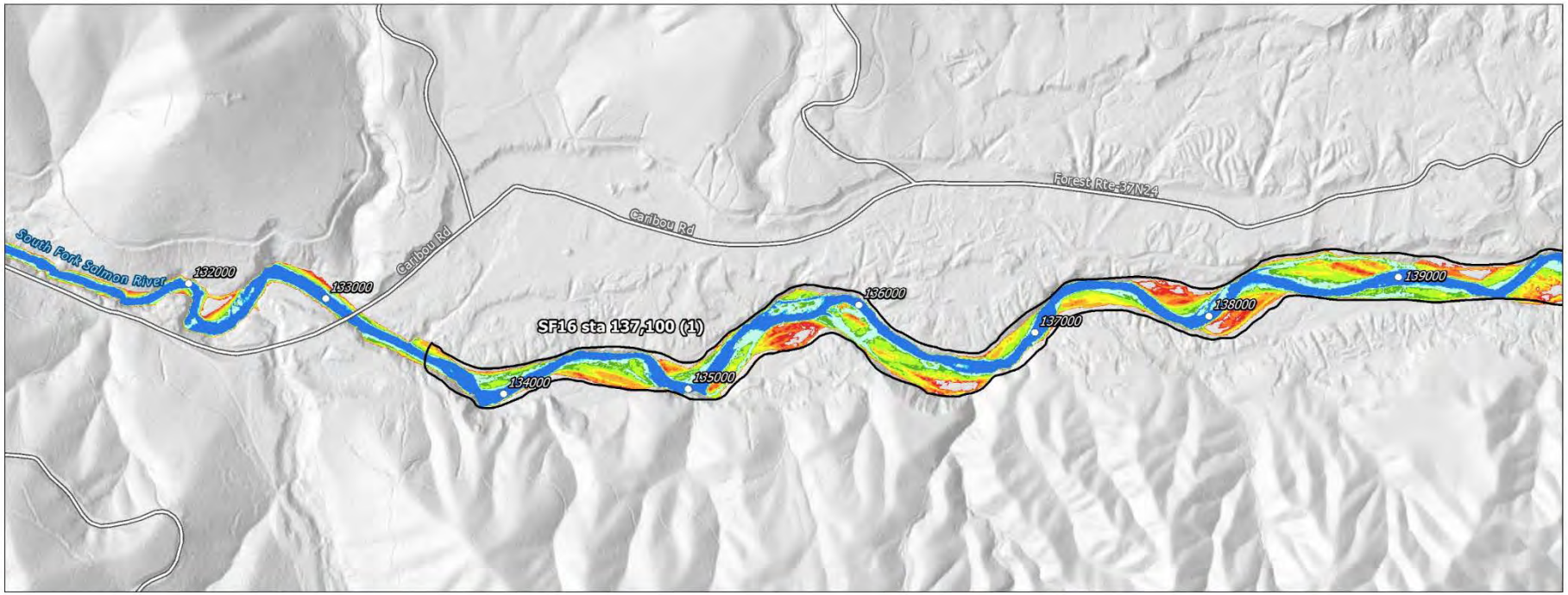

SF9 sta 52,800 (1)
NAIP 2016
Matthews Creek
52000
53000
54000
South Fork Salmon River
1,000 ft stationing
100 year floodplain
0
75
150
Feet

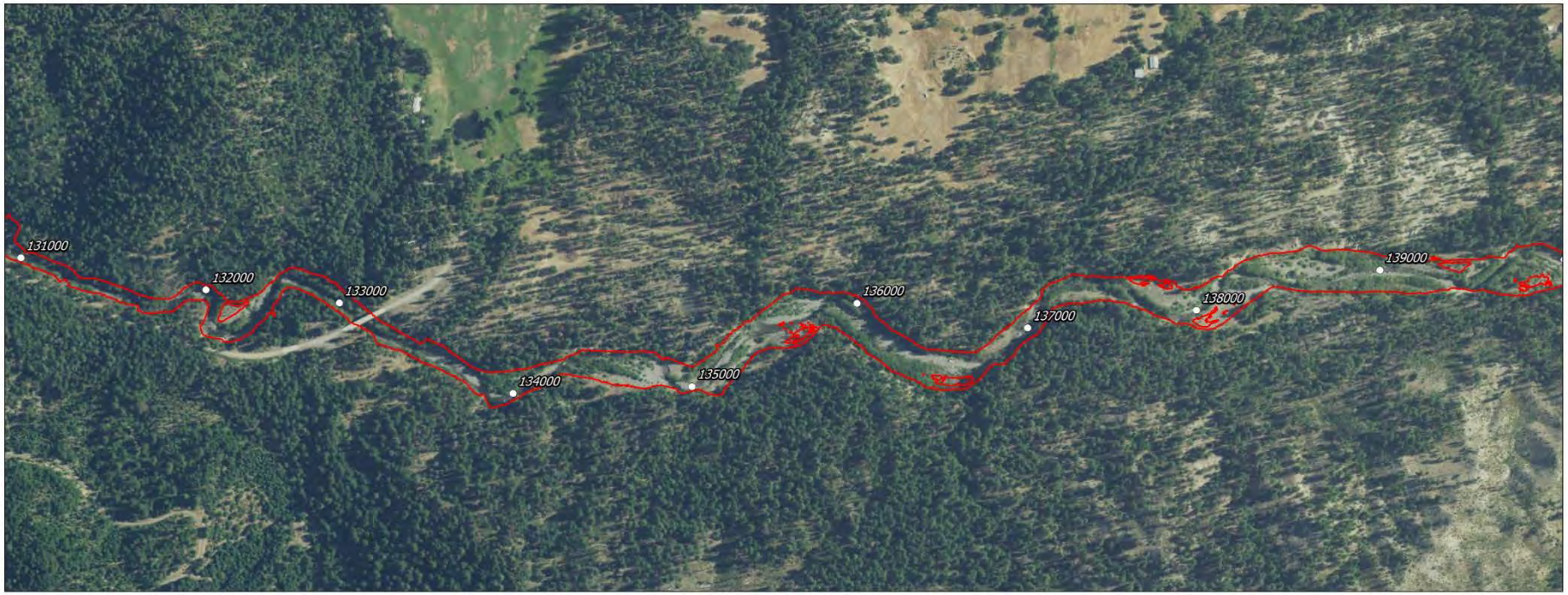

SF9 sta 52,800 (1)
Inundation
Matthews Creek
52000
53000
54000
South Fork Salmon River
1,000 ft stationing
20% exceedance flow
1.5 year peak flow
2 year peak flow
5 year peak flow
10 year peak flow
0
75
150
Feet


SF9 sta 52,800 (1)
Velocities – 20% Exceedance Flow
Matthews Creek
52000
53000
54000
South Fork Salmon River
1,000 ft stationing
Flow depth < 0.5 ft
Flow velocity, ft/sec
0 - 0.5
0.5 - 1
1 - 1.5
1.5 - 2
2 - 3
3 - 4
4 - 5
5 - 6
> 6
0
75
150
Feet


SF9 sta 52,800 (1)
Velocities – 1.5 year Peak Flow
Matthews Creek
52000
53000
54000
South Fork Salmon River
1,000 ft stationing
Flow depth < 0.5 ft
Flow velocity, ft/sec
0 - 0.5
0.5 - 1
1 - 1.5
1.5 - 2
2 - 3
3 - 4
4 - 5
5 - 6
> 6
0
75
150
Feet


SF9 sta 52,800 (1)
Geomorphic Mapping
Matthews Creek
South Fork Salmon River
52000
53000
54000
Top of bank
1,000 ft stationing
Stable bar
Active bar
Wetted Baseflow Channel
Low Flow Side Channel
Bankfull Side Channel
High Flow Side Channel
Lateral Bar
Medial Bar
Bedrock
Floodplain
Terrace
Disturbed
0
100
200
Feet





Salmon River Floodplain Habitat Enhancement and Mine Tailing Remediation Feasibility Study

Reach 16 (South Fork)

DATA SOURCES
LiDAR: Quantum Spatial, 2014
Roads, cities, streams: ESRI 2015
Imagery: NAIP 2016

MAP PROJECTION
NAD_1983_HARN_StatePlane
California I_FIPS_0401_Feet

Stillwater Sciences

LEGEND

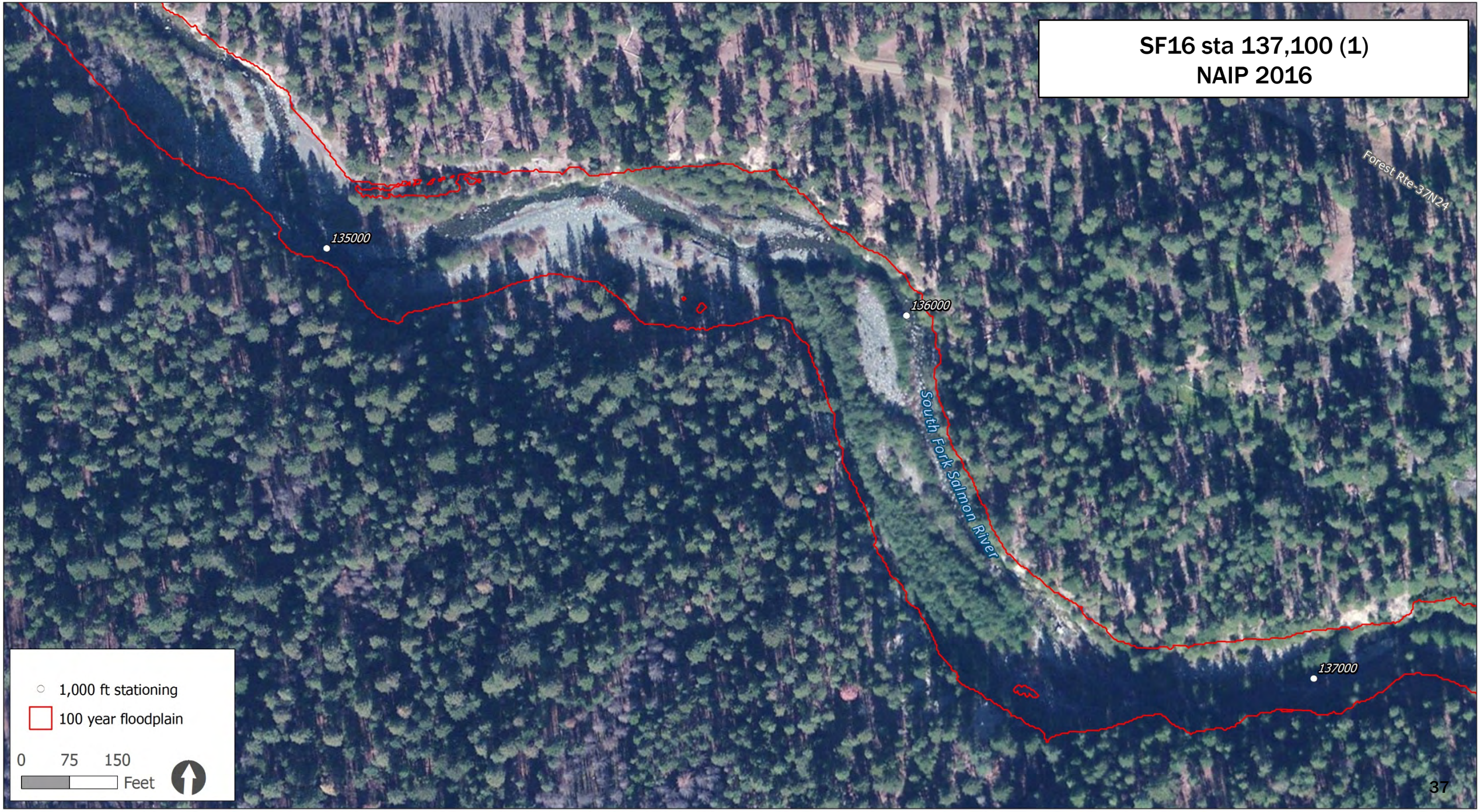
- Potential floodplain enhancement segment
  - MS2 sta 11,650 (1)
  - fork | reach | segment midpoint | suitability rating
- Potential terrace revegetation sites with mine tailings
- Existing and potential off-channel ponds with potential for channel connection
- 100 year floodplain
- Reach break
- 1000-ft stationing

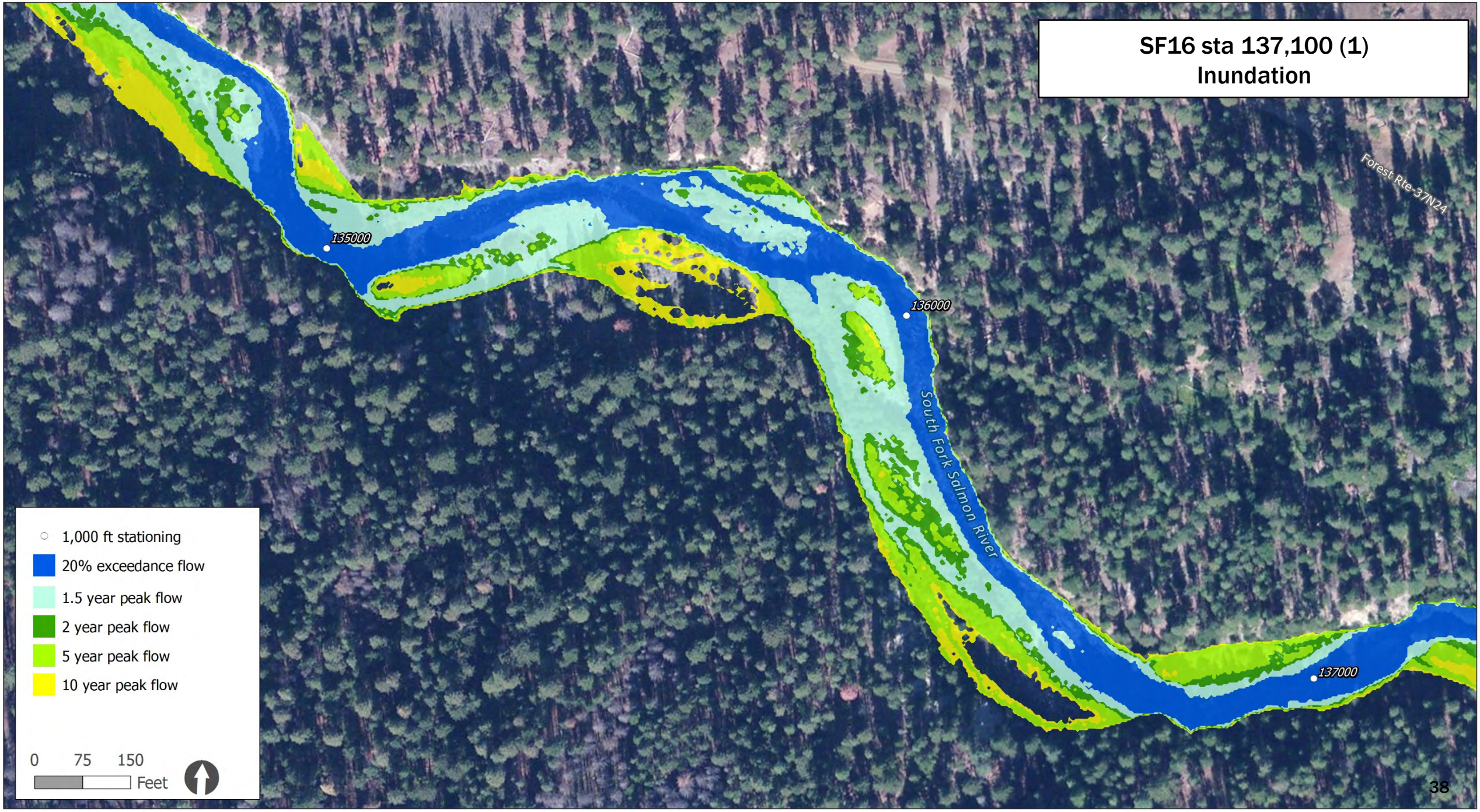
Modeled Inundation

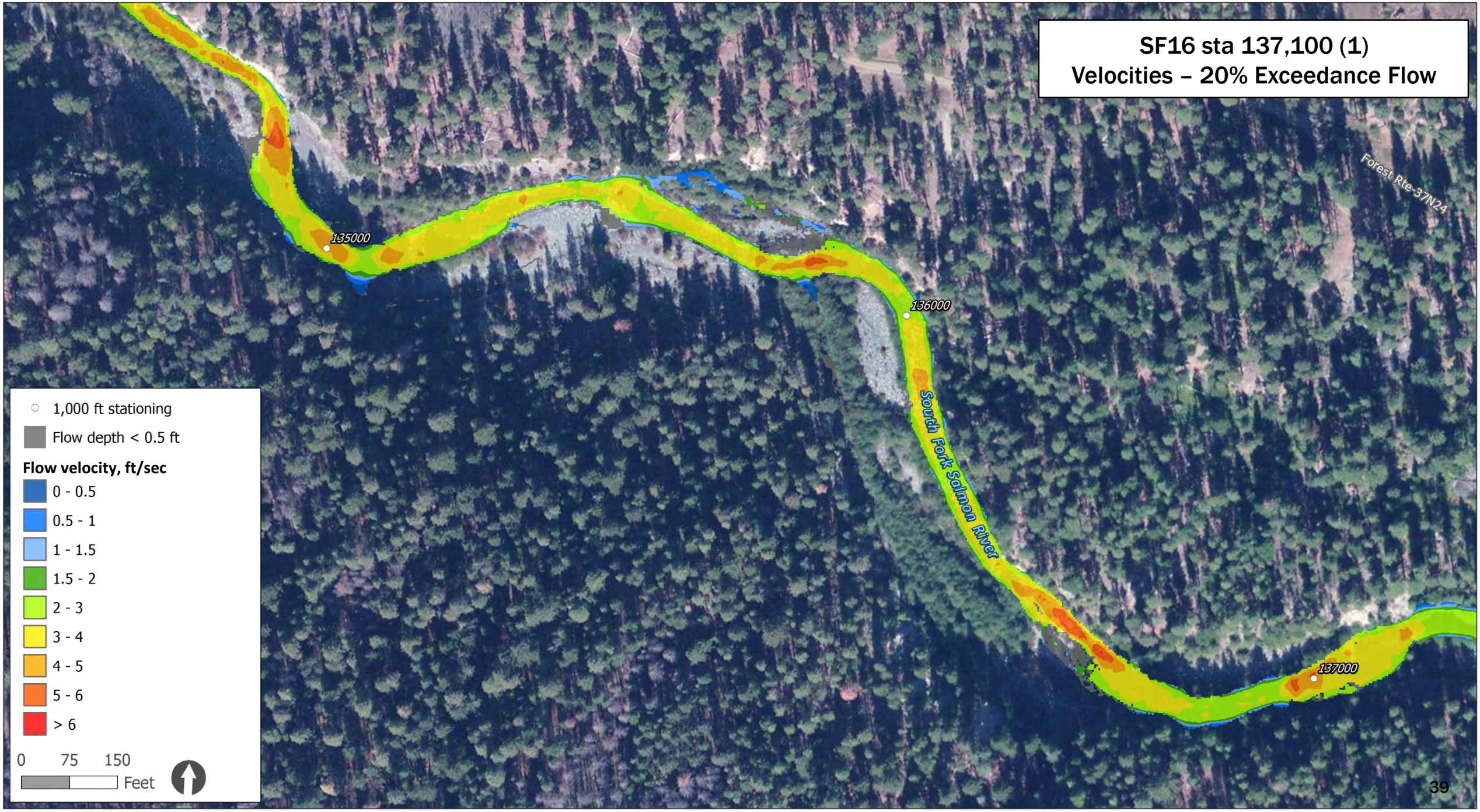
- 20% exceedance flow
- 1/2 of the 1.5 year peak flow
- 1.5 year peak flow
- 2 year peak flow
- 5 year peak flow
- 10 year peak flow
- 25 year peak flow
- 50 year peak flow
- 100 year peak flow

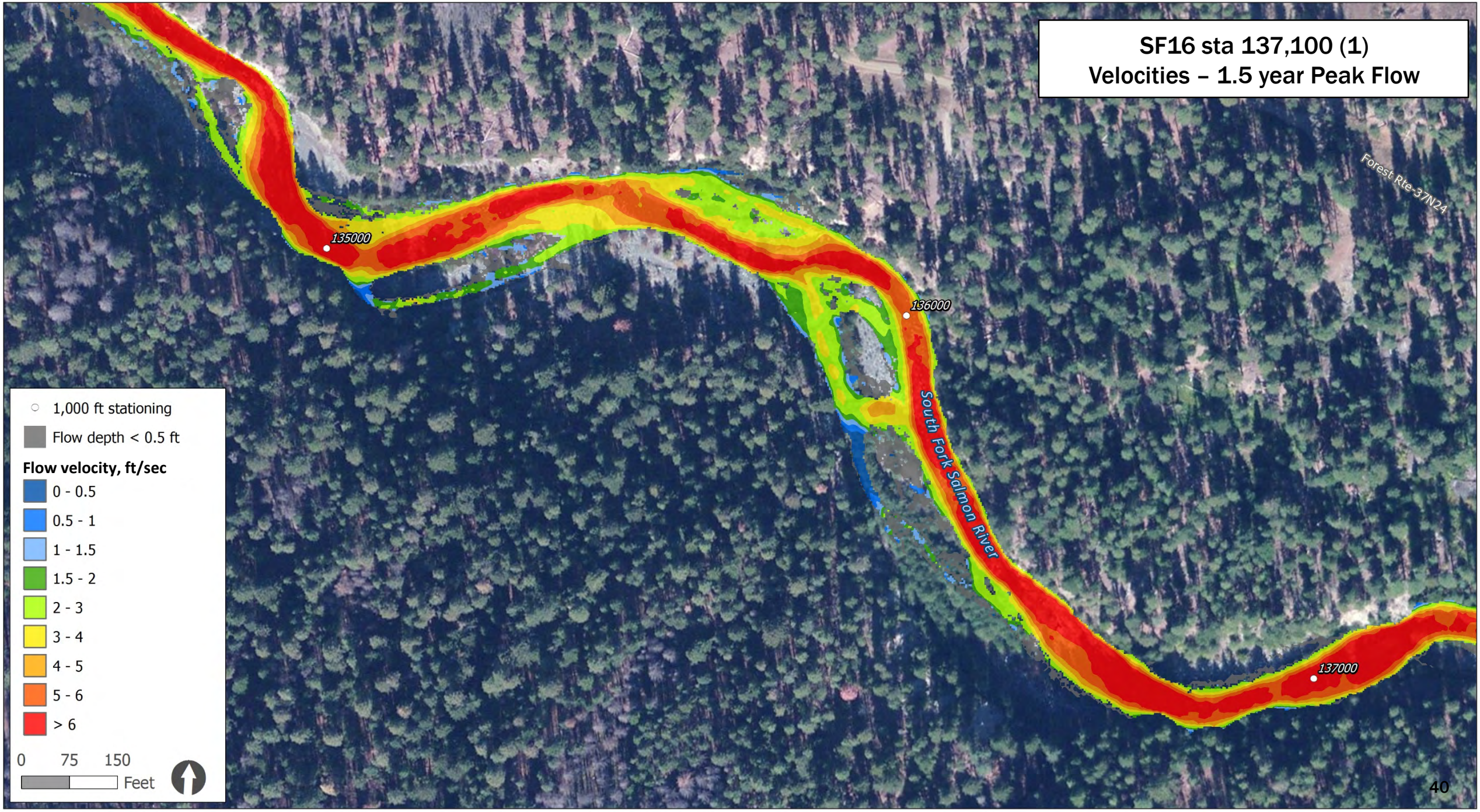
0 250 500 1,000 Feet
0 50 100 200 Meters
1:6,500 1 in = 542 feet

MAP LOCATION pg 15 of 26

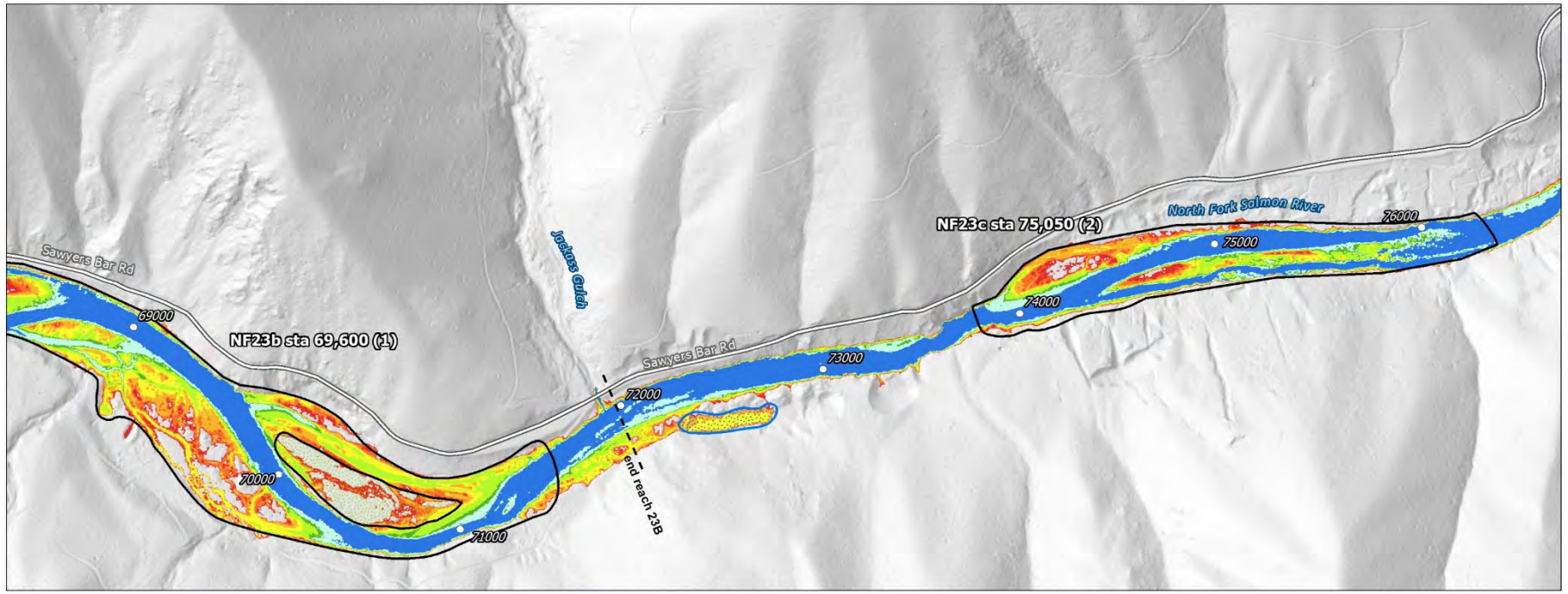

SF16 sta 137,100 (1)
NAIP 2016
135000
136000
137000
South Fork Salmon River
Forest Rte-37N24
1,000 ft stationing
100 year floodplain
0 75 150
Feet


SF16 sta 137,100 (1)
Inundation
135000
136000
137000
South Fork Salmon River
Forest Rte-37N24
1,000 ft stationing
20% exceedance flow
1.5 year peak flow
2 year peak flow
5 year peak flow
10 year peak flow
0
75
150
Feet


SF16 sta 137,100 (1)
Velocities – 20% Exceedance Flow
135000
136000
137000
South Fork Salmon River
Forest Rte-37N24
1,000 ft stationing
Flow depth < 0.5 ft
Flow velocity, ft/sec
0 - 0.5
0.5 - 1
1 - 1.5
1.5 - 2
2 - 3
3 - 4
4 - 5
5 - 6
> 6
0 75 150
Feet


SF16 sta 137,100 (1)
Velocities – 1.5 year Peak Flow
135000
136000
137000
South Fork Salmon River
Forest Rte-37N24
1,000 ft stationing
Flow depth < 0.5 ft
Flow velocity, ft/sec
0 - 0.5
0.5 - 1
1 - 1.5
1.5 - 2
2 - 3
3 - 4
4 - 5
5 - 6
> 6
0 75 150
Feet


SF16 sta 137,100 (1)
Geomorphic Mapping
135000
136000
137000
South Fork Salmon River
Top of bank
1,000 ft stationing
Stable bar
Active bar
Wetted Baseflow Channel
Low Flow Side Channel
Bankfull Side Channel
Alcove
Lateral Bar
Medial Bar
Bedrock
Floodplain
Terrace
0
100
200
Feet



Salmon River Floodplain and Mine Tailing Restoration and Enhancement Opportunities

Reach 23B & 23C (North Fork)

DATA SOURCES
LiDAR: Quantum Spatial, 2014
Roads, cities, streams: ESRI 2015
Imagery: NAIP 2016

MAP PROJECTION
NAD_1983_HARN_StatePlane California_I_FIPS_0401_Feet

Stillwater Sciences

LEGEND

- Potential floodplain fisheries habitat enhancement segments
  - MS2 sta 11,650 (1)
  - fork – reach – segment midpoint – suitability rating
- Potential terrace revegetation sites with mine tailings
- Existing and potential off-channel ponds with potential for channel connection
- 100 year floodplain
- Reach break
- 1000-ft stationing

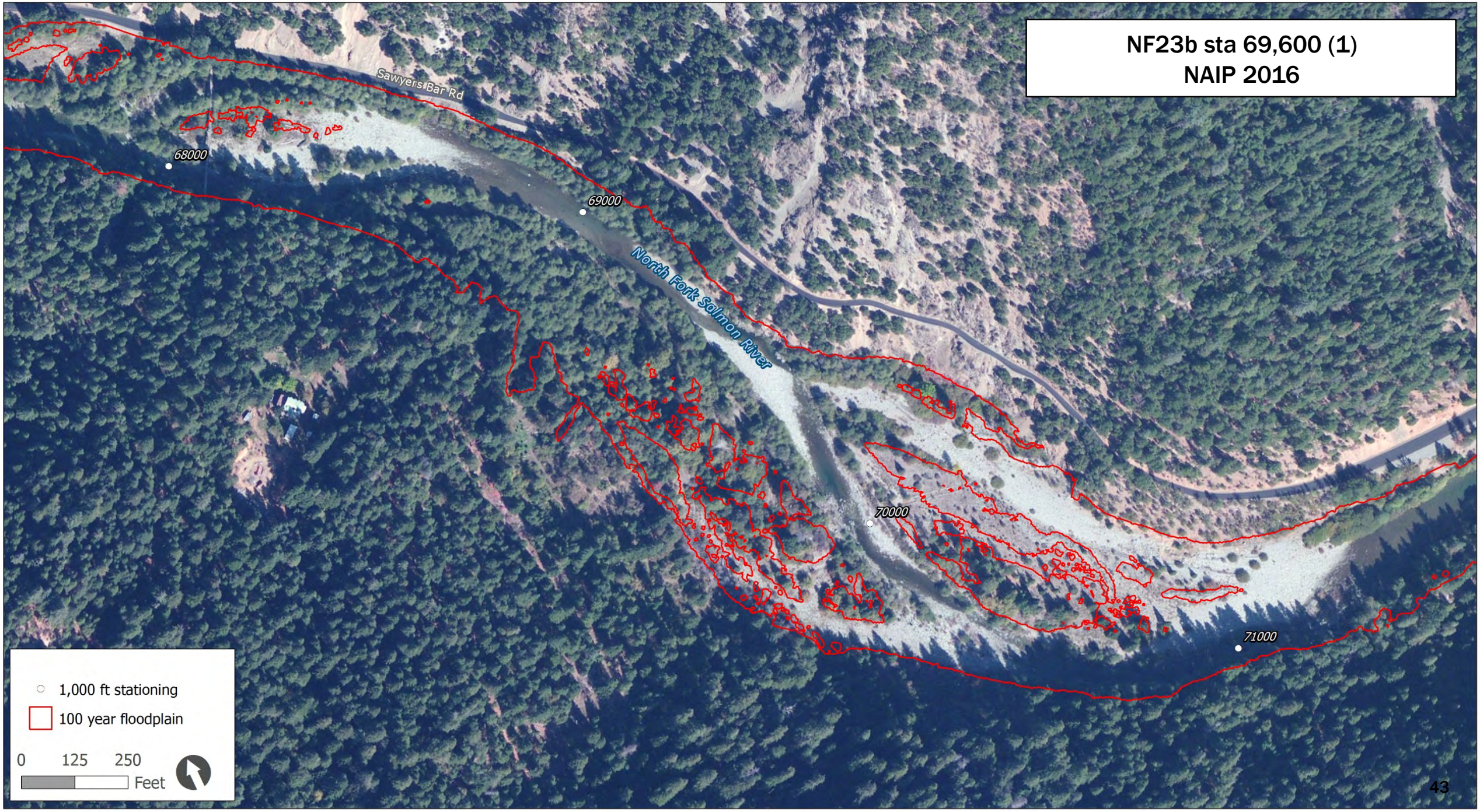
Modeled Inundation

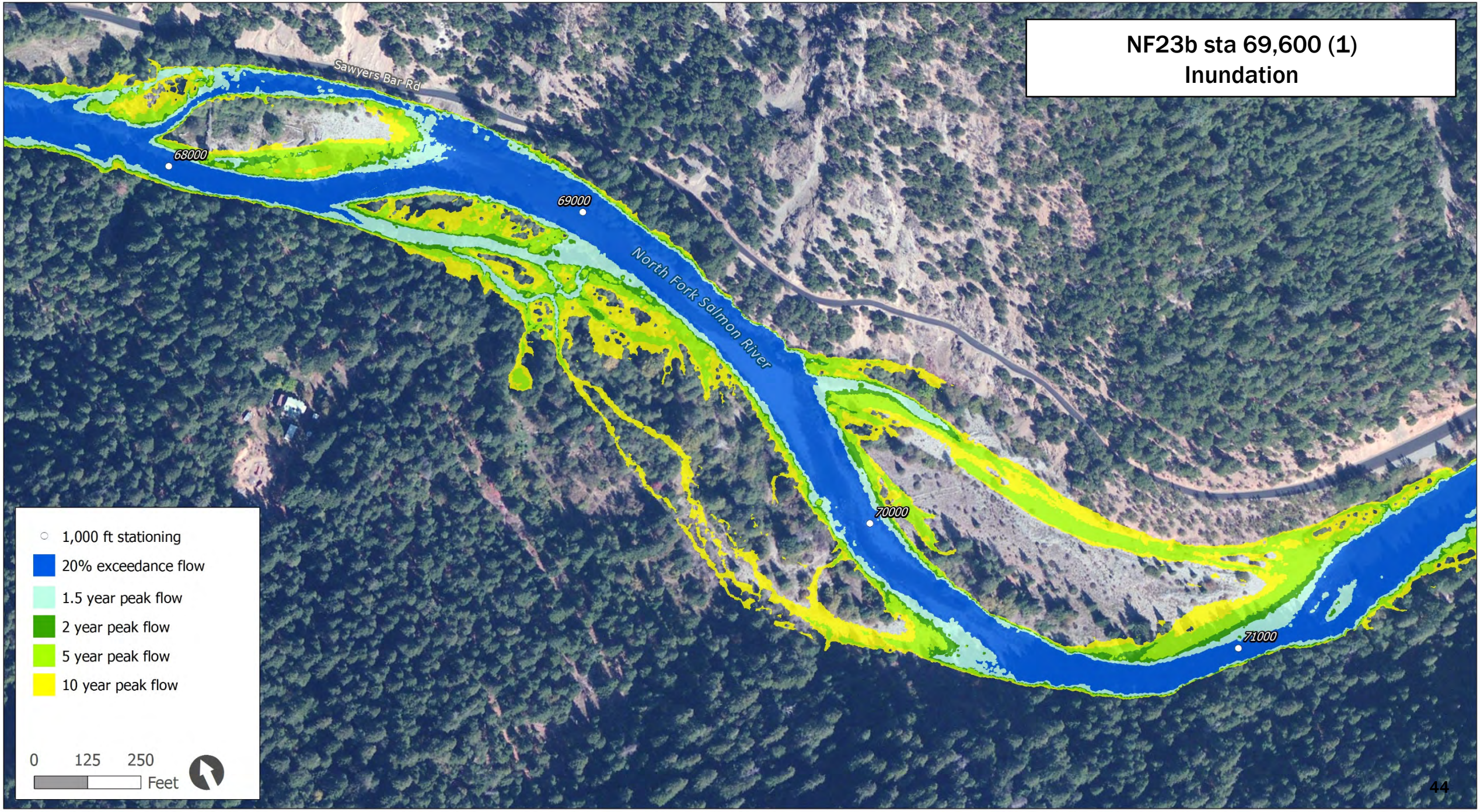
- 20% exceedance flow
- 1.5 year peak flow
- 2 year peak flow
- 5 year peak flow
- 10 year peak flow
- 25 year peak flow
- 50 year peak flow
- 100 year peak flow

0 250 500 1,000 Feet
0 50 100 200 Meters

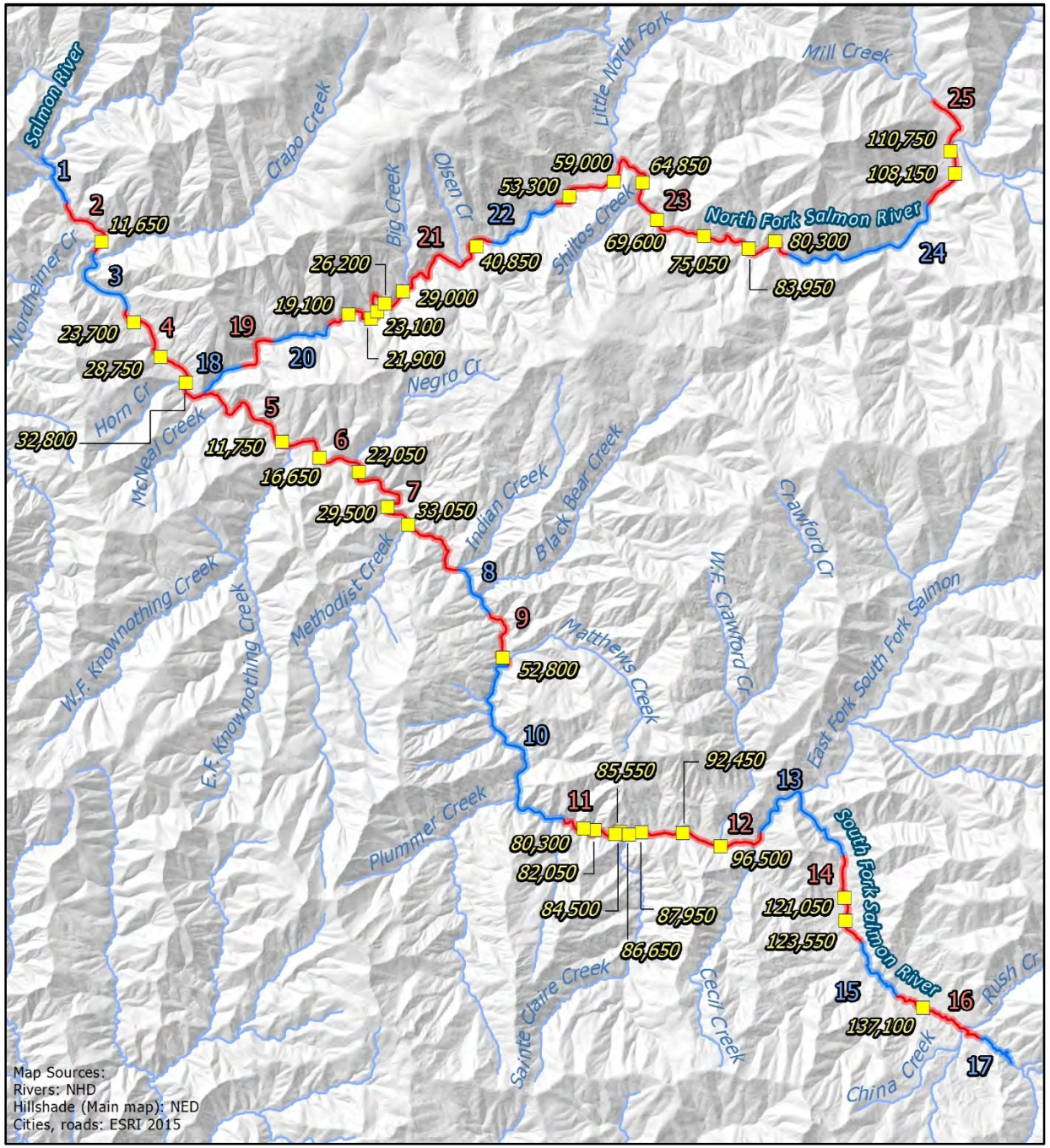
1:6,500 1 in = 542 feet

MAP LOCATION *pg 23 of 26*


NF23b sta 69,600 (1)
NAIP 2016
Sawyers Bar Rd
68000
69000
North Fork Salmon River
70000
71000
1,000 ft stationing
100 year floodplain
0
125
250
Feet


NF23b sta 69,600 (1)
Inundation
Sawyers Bar Rd
North Fork Salmon River
68000
69000
70000
71000
1,000 ft stationing
20% exceedance flow
1.5 year peak flow
2 year peak flow
5 year peak flow
10 year peak flow
0
125
250
Feet

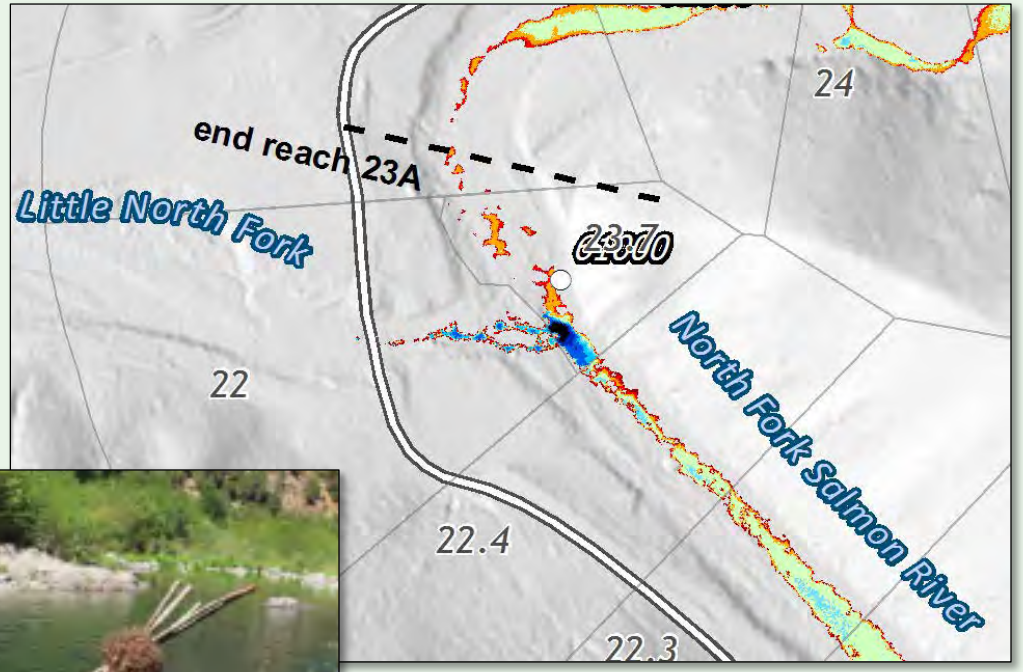

Sawyers Bar Rd
68000
69000
North Fork Salmon River
70000
71000
Top of bank
1,000 ft stationing
Stable bar
Active bar
Wetted Baseflow Channel
Low Flow Side Channel
Bankfull Side Channel
High Flow Side Channel
Alcove
Lateral Bar
Medial Bar
Floodplain
Terrace
Disturbed
0
125
250
Feet



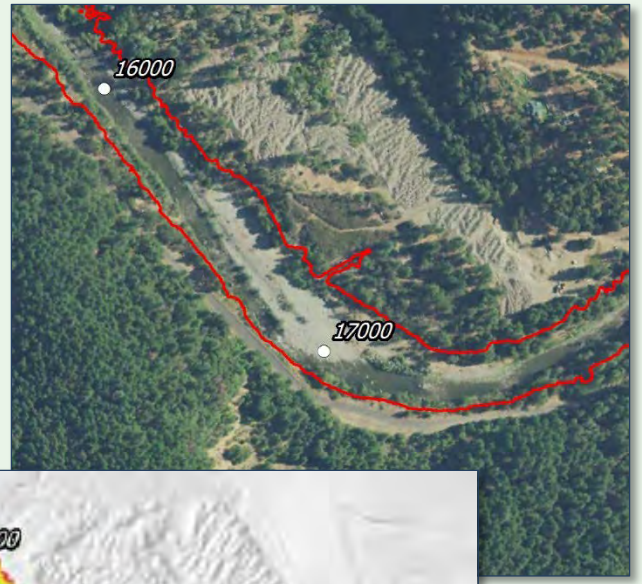
PROJECT TREATMENTS TO IMPROVE THERMAL, HYDROLOGIC, AND GEOMORPHIC FUNCTIONS

1. Enhance and expand cold water refugia and increase riparian shading to improve summer rearing conditions
2. Grade and revegetate floodplains and mine tailings to reduce heating, increase inundation frequency, and improve connectivity
3. Add structural complexity to side-channels and main channel margins to improve rearing habitat
4. Create in-channel structures that promote sorting to improve spawning habitat and summer rearing habitat
5. Create, enhance, and connect off-channel ponds and wetlands to improve winter habitat

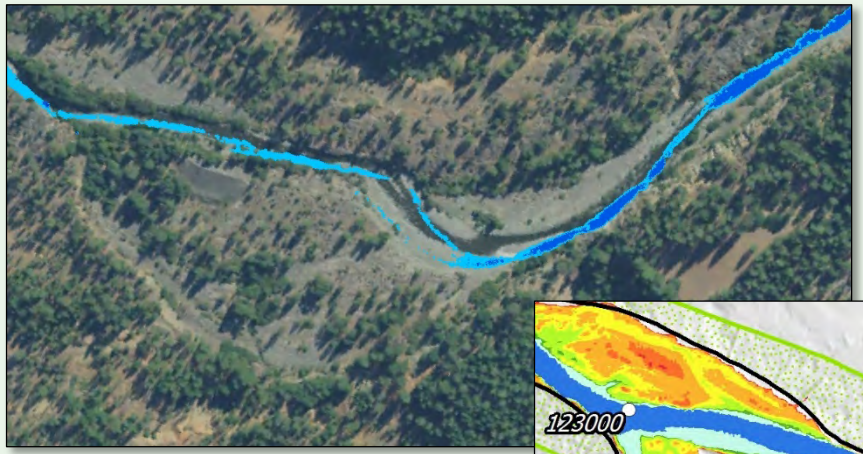
ENHANCE AND EXPAND COLD WATER REFUGE HABITAT

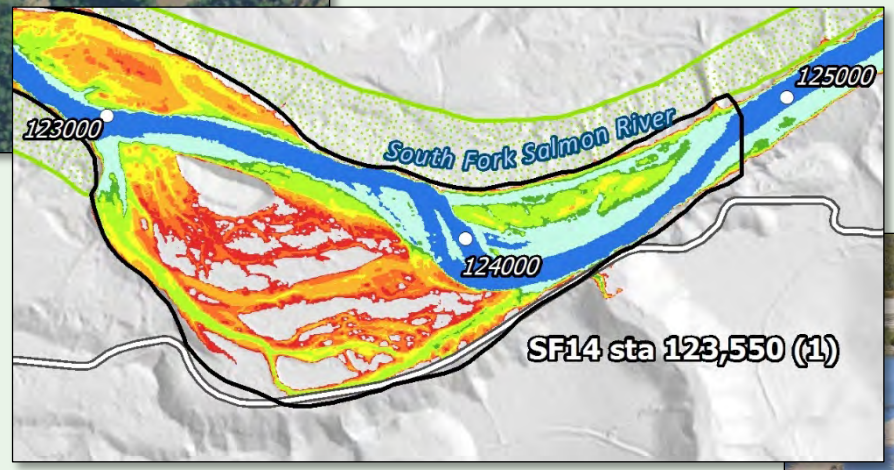


GRADE AND REVEGETATE FLOODPLAINS AND MINE TAILINGS

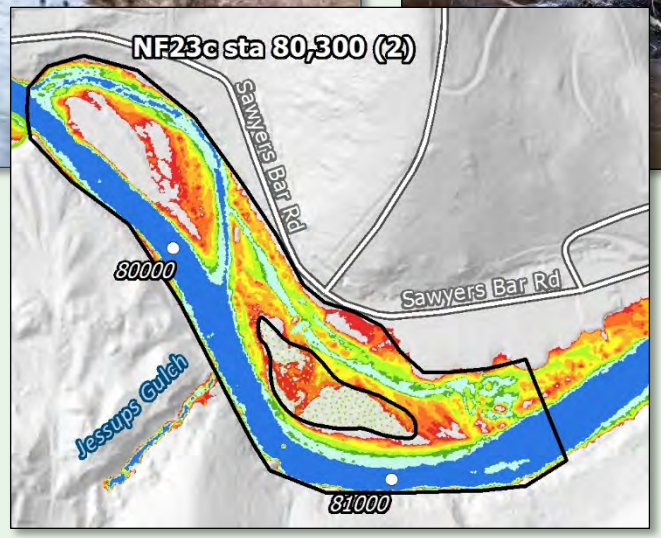


RECONNECT FLOODPLAINS



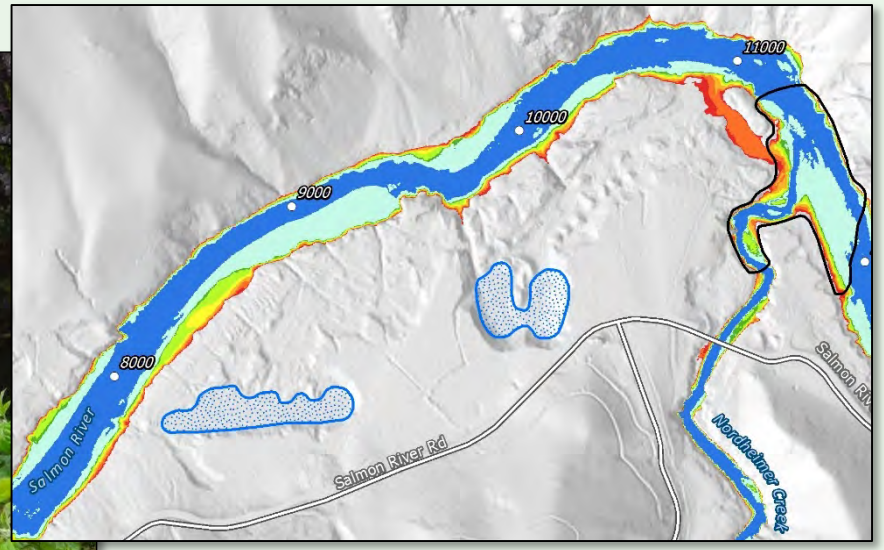


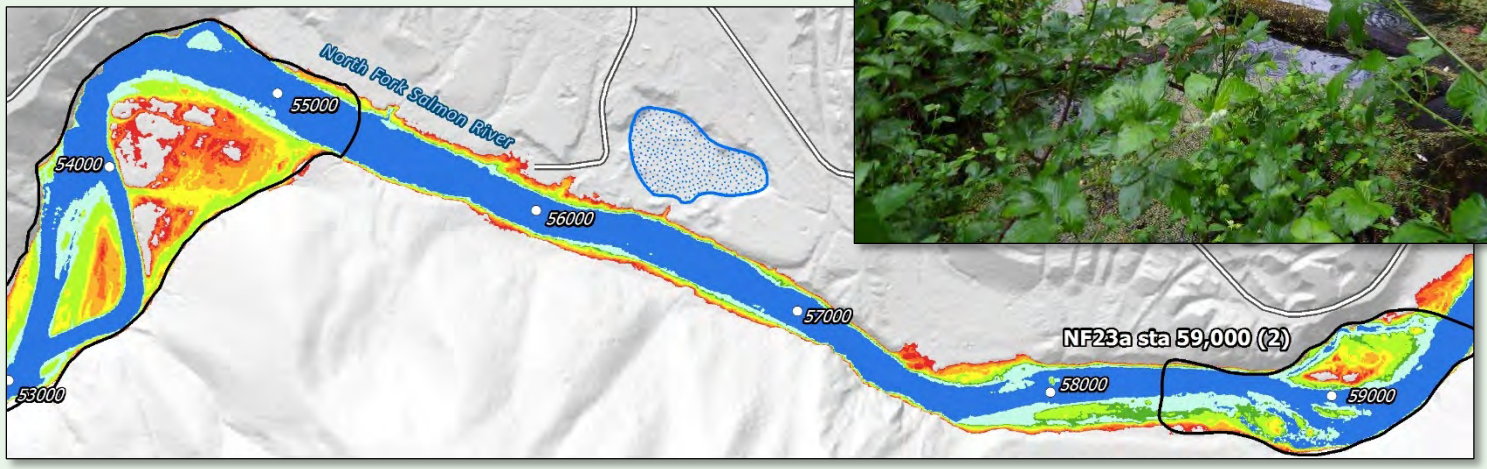
ADD STRUCTURAL COMPLEXITY TO SIDE-CHANNELS AND MAIN CHANNEL MARGINS



CREATE IN-CHANNEL STRUCTURES

CREATE, ENHANCE, AND CONNECT OFF-CHANNEL PONDS AND WETLANDS





NEXT STEPS

- **Spawning gravel mapping and spawner capacity estimate**
- **Site-specific field mapping and verification of opportunities and constraints**
- **Conceptual site designs at priority sites**
- **System-wide cultural resource assessment**
- **Programmatic NEPA**

For more Information:

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25631 Sawyers Bar Road
Sawyers Bar, CA 96027
530.462.4665
srrc.org