Concrete Sauk Valley Road Bank Stabilization at Milepost 13

WILD, SCENIC AND BEYOND!
RIVER MANAGEMENT SYMPOSIUM

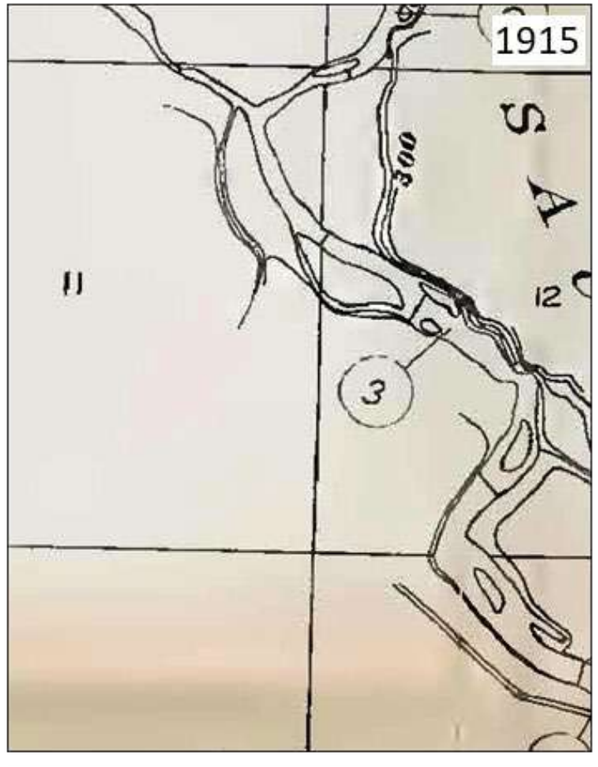
WILD & SCENIC
50 YEARS 1968–2018
RIVERS

Natural Systems Design

October 23, 2018

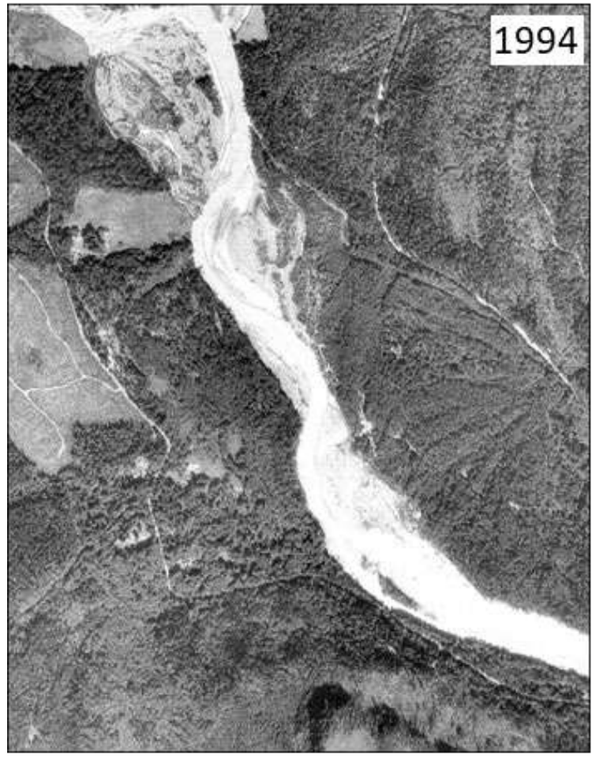
- **Sauk River designated Wild and Scenic November 10, 1978 as part of Public Law 95-625**
- **USDA Forest Service is the administrating agency for Skagit River Management Plan**
- **Review and determination of projects through Section 7a to ACOE and administration (33 CFR 320) of Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act**
- **Sauk River designated “scenic” value**
- **“artificial stabilization will only be used under strict controls and in very limited locations on the Scenic Rivers”**


1884


1915


1944
0
1,000
2,000 ft

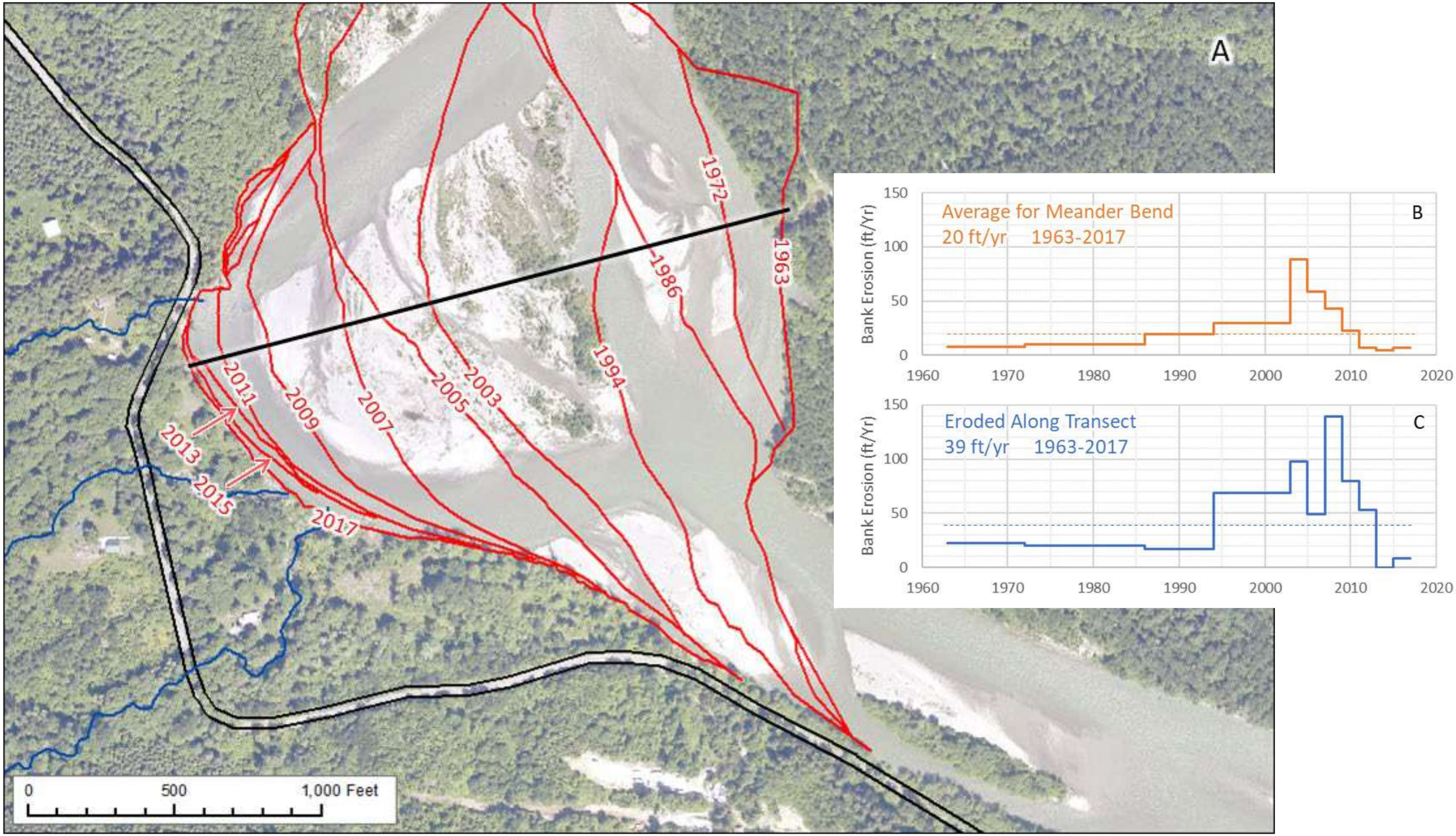

1963


1994

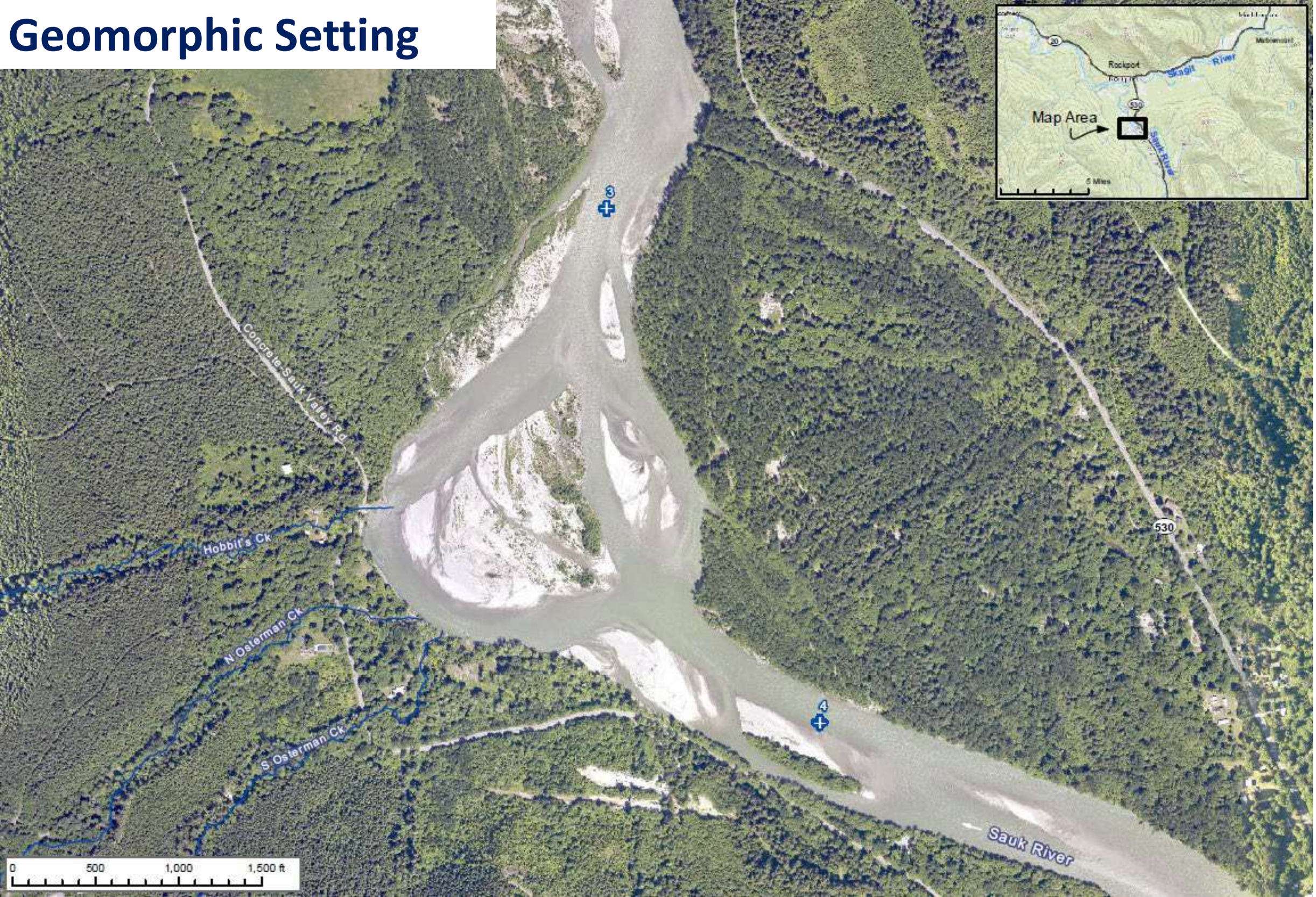

2003


2009
0
1,000
2,000 ft

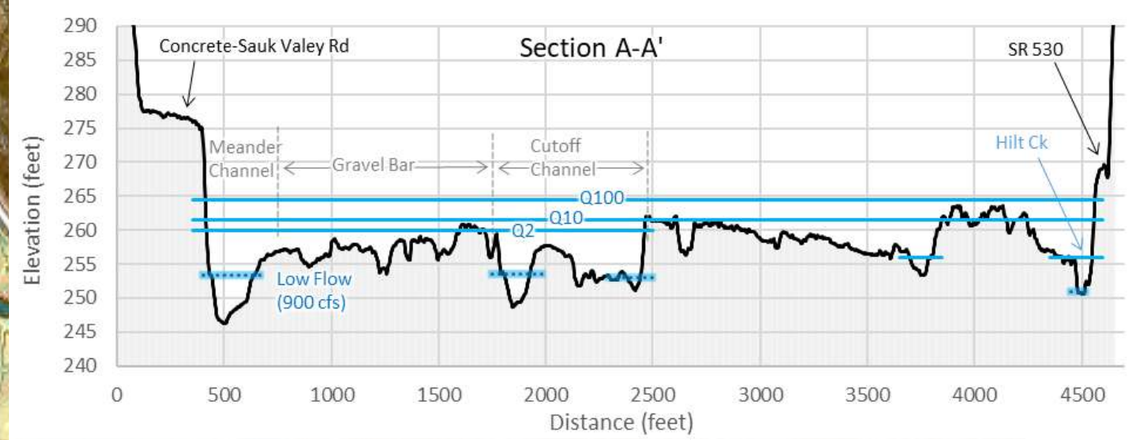

2017


A
1972
1986
1993
1994
2003
2005
2007
2009
2011
2013
2015
2017
0
500
1,000 Feet
B
Average for Meander Bend
20 ft/yr 1963-2017
Bank Erosion (ft/Yr)
150
100
50
0
1960
1970
1980
1990
2000
2010
2020
C
Eroded Along Transect
39 ft/yr 1963-2017
Bank Erosion (ft/Yr)
150
100
50
0
1960
1970
1980
1990
2000
2010
2020

Geomorphic Setting



Geomorphic Setting



Channel Gradient 0.002 – 0.003
Unconfined valley, width ~ 4,500 ft
Moderately confined segment upstream
Channel width ~ 400 ft
Terrace surface (former floodplain)
Alluvial fan from 3 left bank tributaries

Glacial Deposits

Bedrock Outcrop

B'

B

C'

C

Hobbit's Ck

N. Osterman Ck

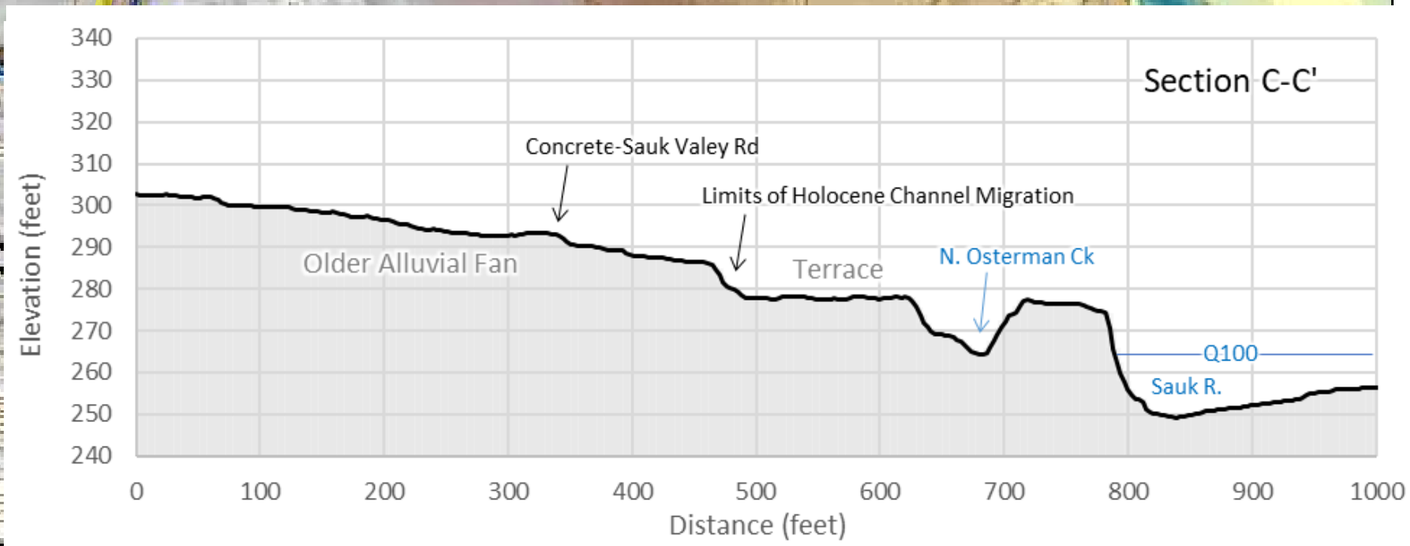
S. Osterman Ck

Sauk River

Alluvial Fan

Alluvial Terrace, draped with younger alluvial fan deposits

0 500 1,000 Feet



121°36'30"W 121°36'0"W 48°27'30"N 121°35'30"W 121°35'0"W 121°34'30"W 121°34'0"W

48°27'30"N 121°37'0"W

48°27'0"N

Legend

- River Mile
- Roads
- Parcel Boundary

Roads: Skagit County 2018

Parcels: Skagit County 2018

Velocity (ft/s)

0
0.1
0.5
1
1.5
2
4
6
8
10
12
15
20

Sauk River

Map Area

0 10 Mile

N

G:\Dooley,NED Date: 9/11/2018 Path: P:\Projects\Skagit County\Concrete-Sauk Road\GIS\maps\mxd\SMS\Sauk_2yr_Velocity.mxd

Concrete-Sauk Valley Road Bank Stabilization Milepost 13

2-Year Flow (38,378 cfs)

Hydronia RiverFlow-2D Plus GPU Hydraulic Model output

N

0 500 1,000 1,500 2,000 Feet

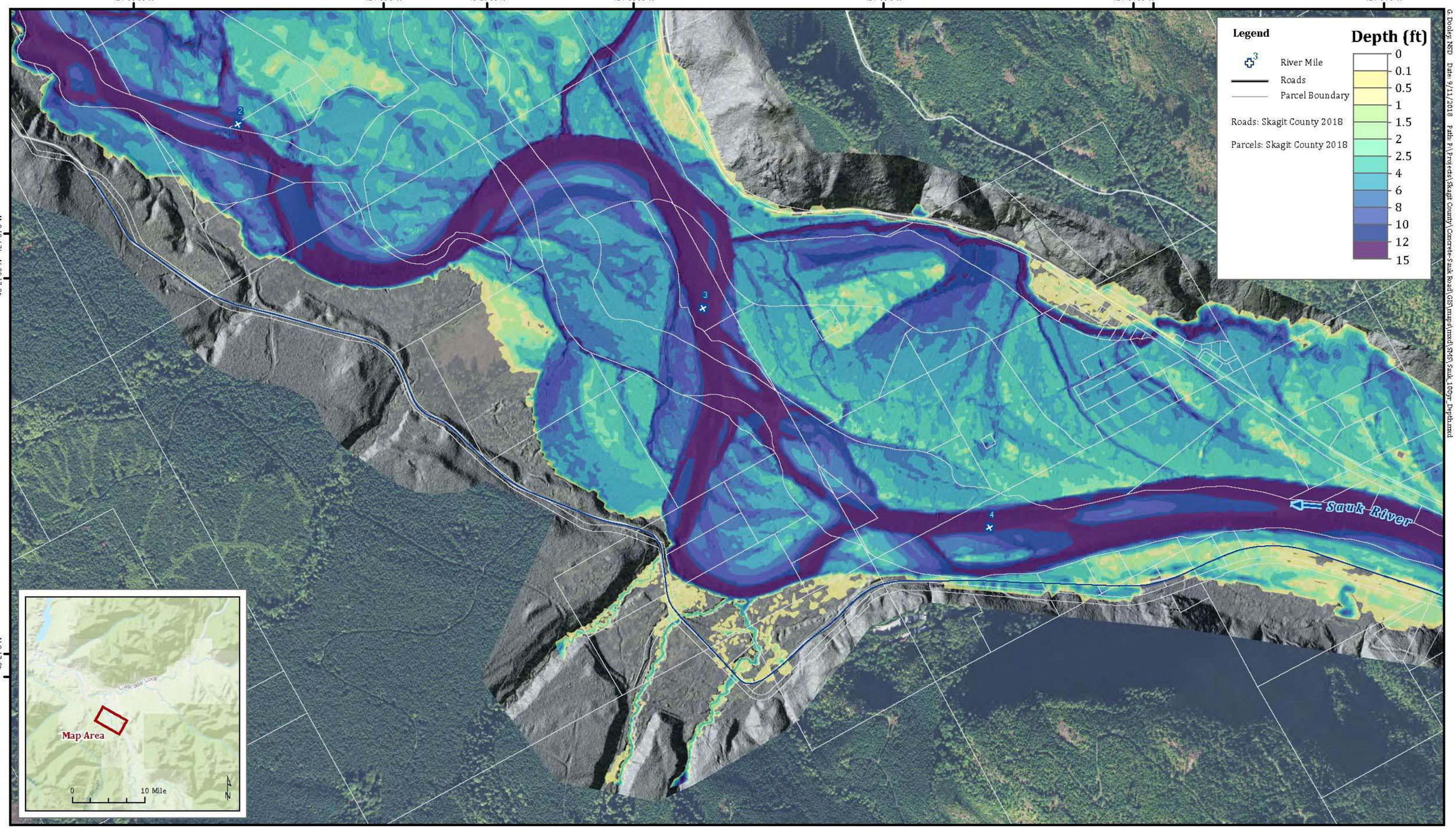
Lambert conformal conic projection, NAD 1983
State Plane Coordinate System (WA North Zone)
- Topography: 2016 LIDAR DEM (PSLC) and 2018 topographic survey.

Natural Systems Design

121°36'30"W 121°36'0"W 48°27'30"N 121°35'30"W 121°35'0"W 121°34'30"W 121°34'0"W

48°27'30"N 121°37'0"W

48°27'0"N



G. Dooley, NSD Date: 9/11/2018 Path: P:\Projects\Skagit County\Concrete-Sauk Road\GIS\maps\mxd\SMS\Sauk_100yr_Depth.mxd

Concrete-Sauk Valley Road Bank Stabilization Milepost 13

100-Year Flow (121,187 cfs)

Hydronia RiverFlow-2D Plus GPU Hydraulic Model output

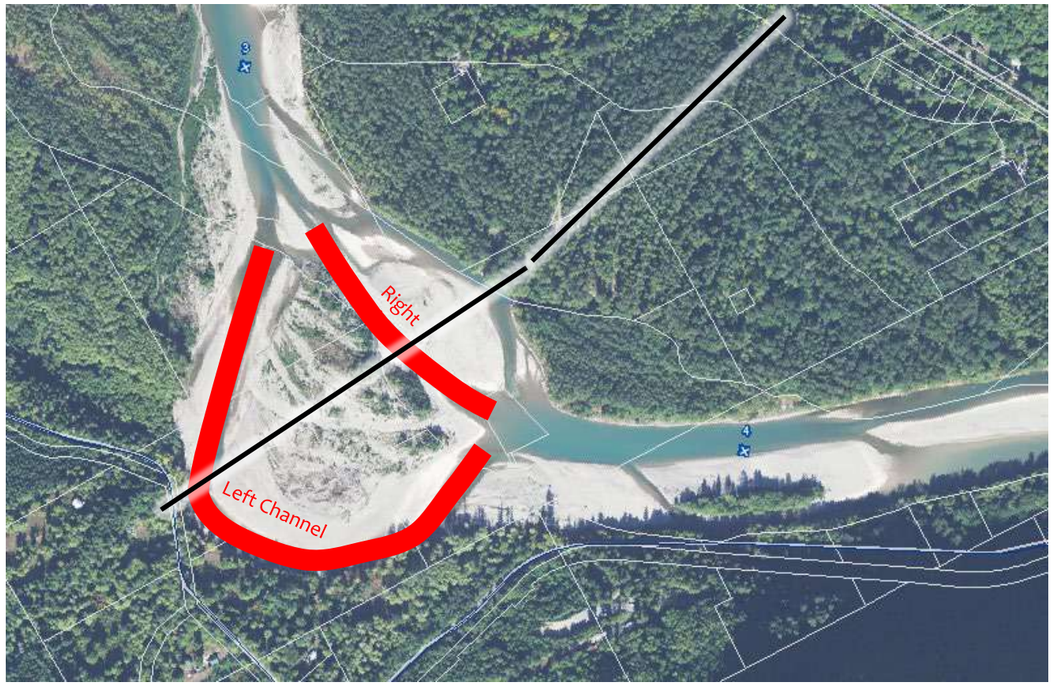
N

0 500 1,000 1,500 2,000 Feet

Lambert conformal conic projection, NAD 1983
State Plane Coordinate System (WA North Zone)
- Topography: 2016 LIDAR DEM (PSLC) and 2018 topographic survey.

Natural Systems Design

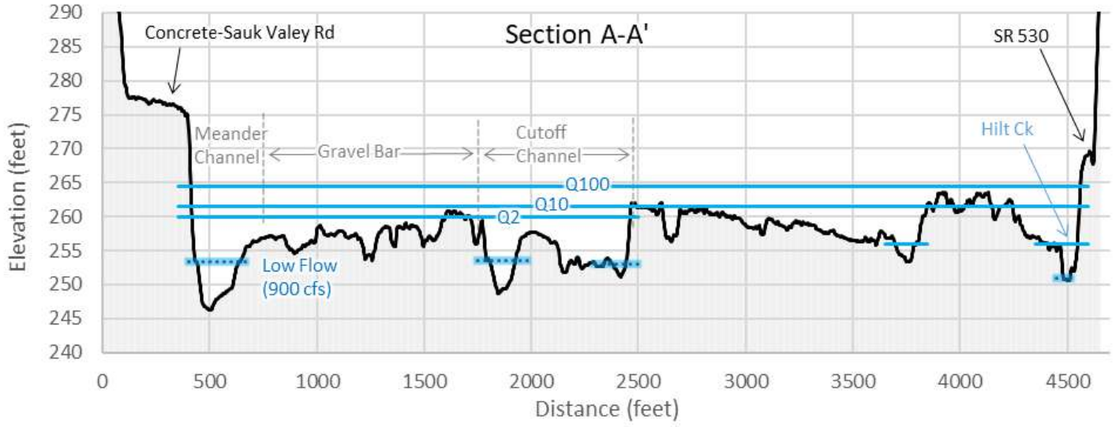
Flow Split and Cutoff Development



Cutoff channel has become dominant flowpath

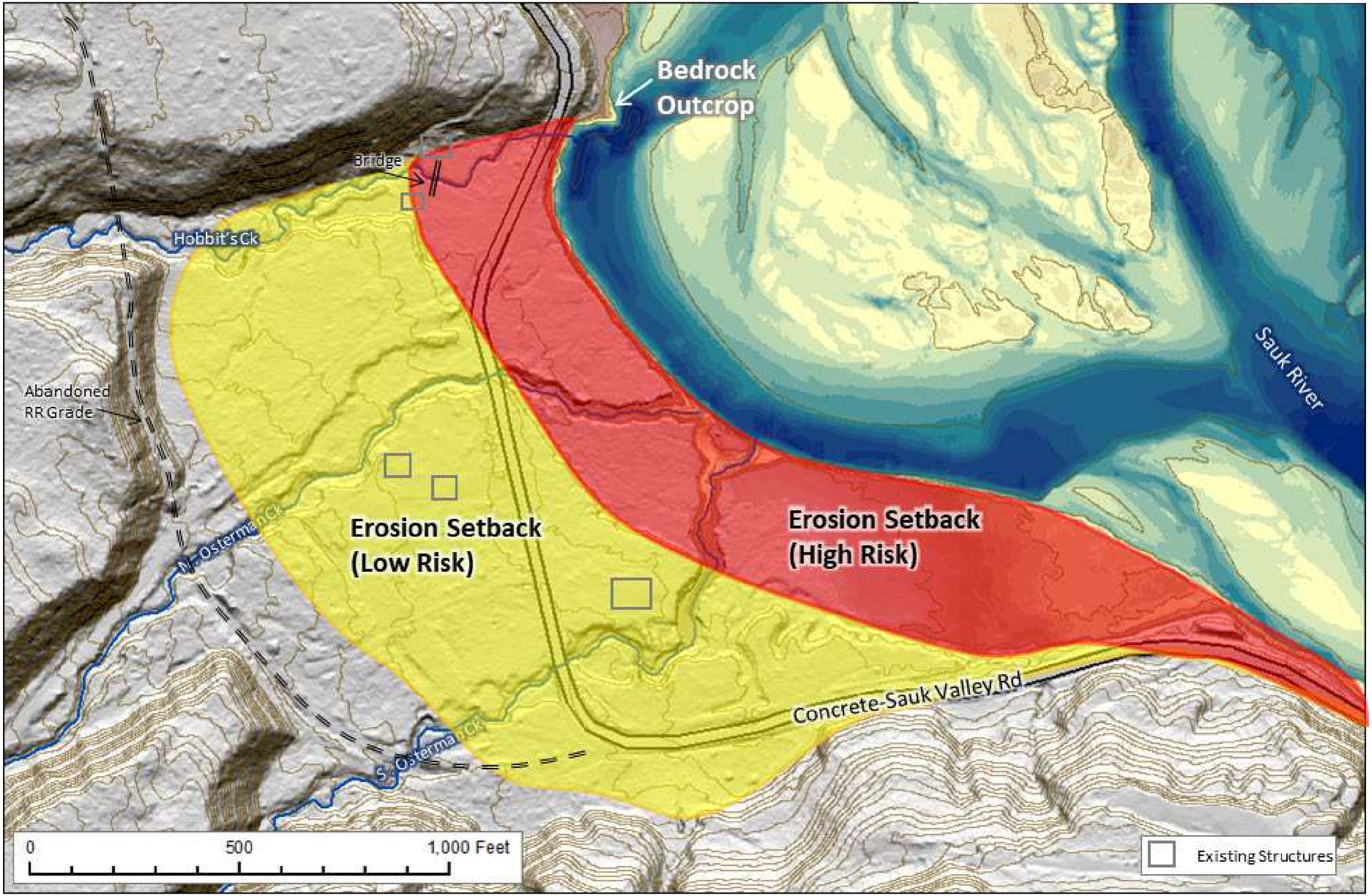
- **Shorter distance / Steeper gradient**
- **At Q10, both flow and velocity in cutoff channel > 2x flow in meander**
- **Relative difference increase with discharge**

Cutoff channel actively widening (erosion right bank)

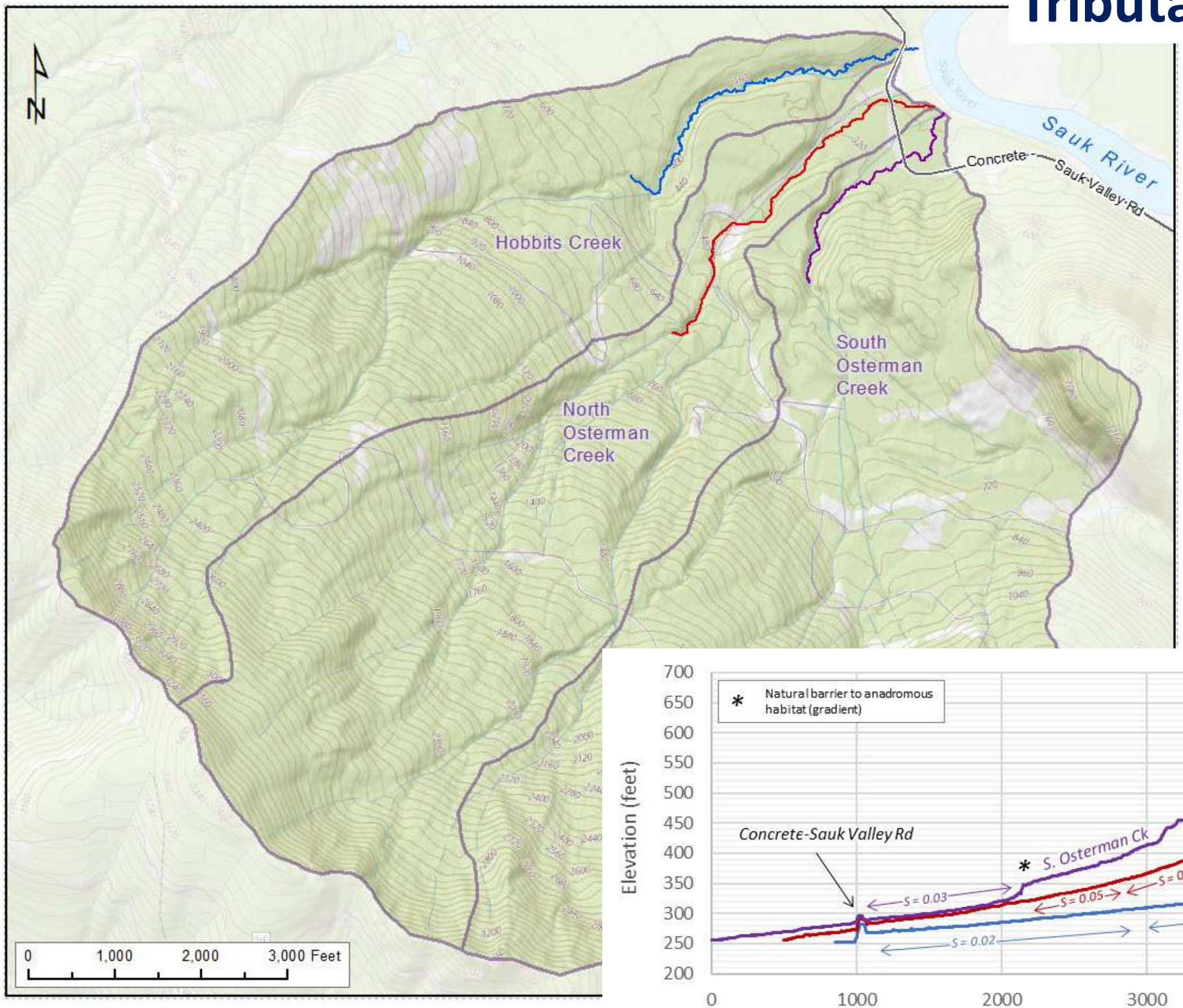


SIMULATION	LEFT CHANNEL FLOW (CFS) AND % OF TOTAL FLOW*	AVG LEFT CHANNEL VELOCITY (FT/S)*	RIGHT CHANNEL FLOW (CFS) AND % OF TOTAL FLOW**	AVG RIGHT CHANNEL VELOCITY (FT/S)**	FLOODPLAIN Q***
2-yr Peak Flow	8,100 (21%)	6	13,400 (35%)	9.5	44%
10-yr Peak Flow	9,700 (14%)	6	22,900 (32%)	15	54%
25-yr Peak Flow	9,500 (10%)	5	27,000 (28%)	16	62%
100-yr Peak Flow	8,300 (7%)	4	31,200 (26%)	16	67%

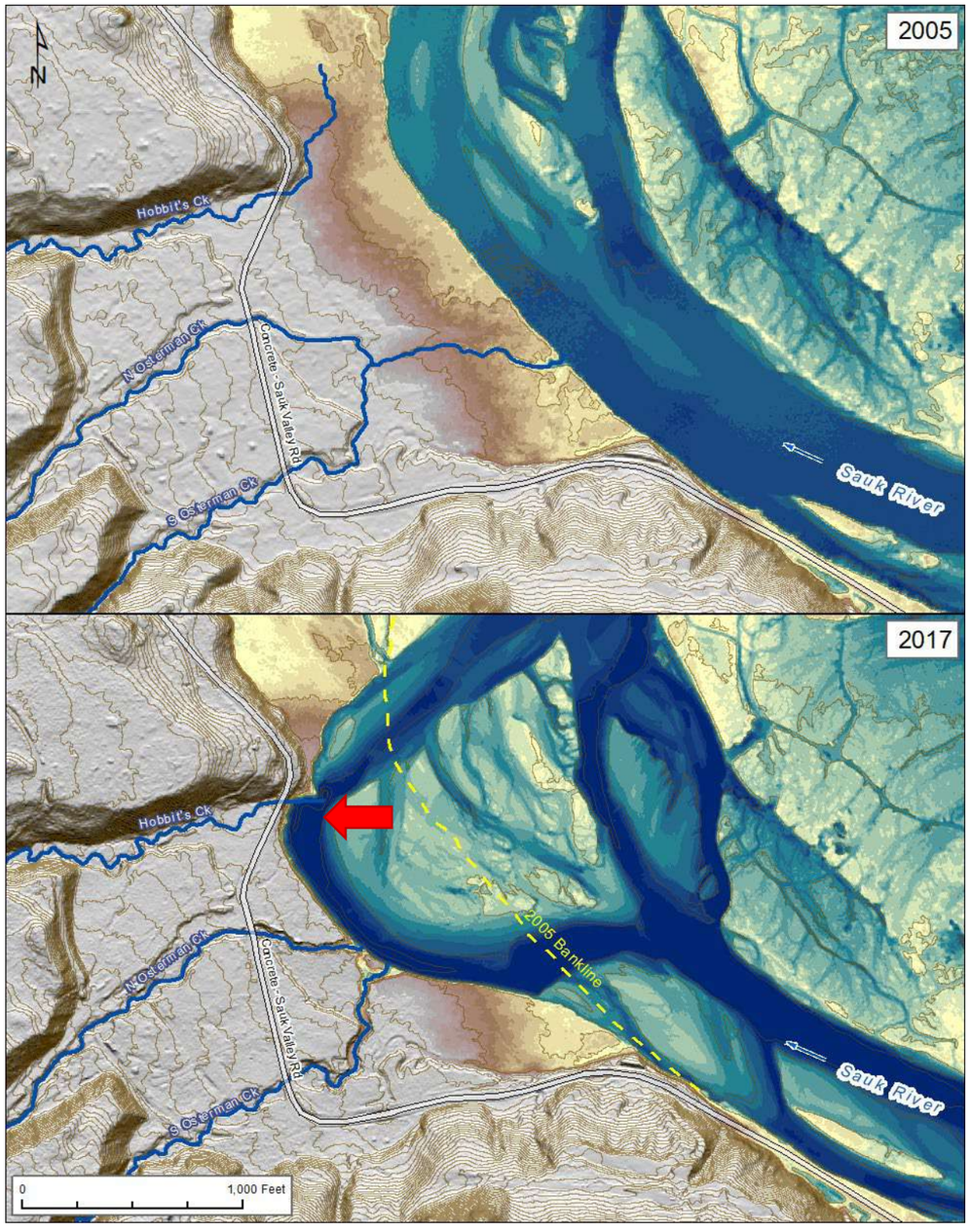
Erosion Hazards

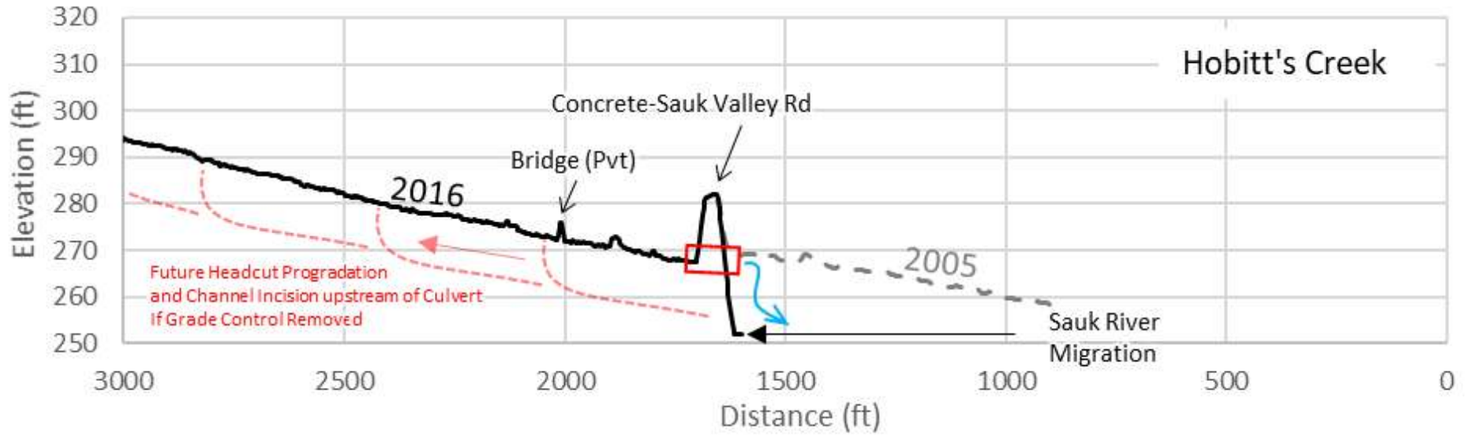


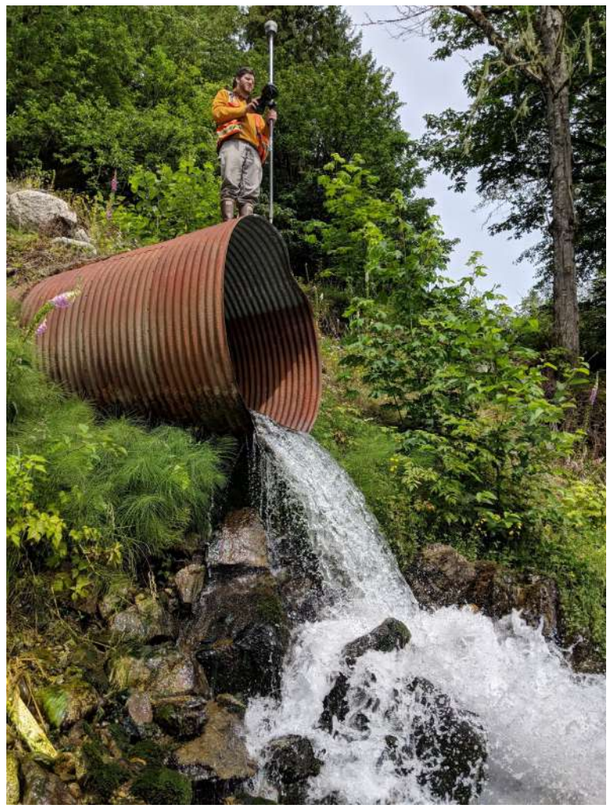
Tributary Incision

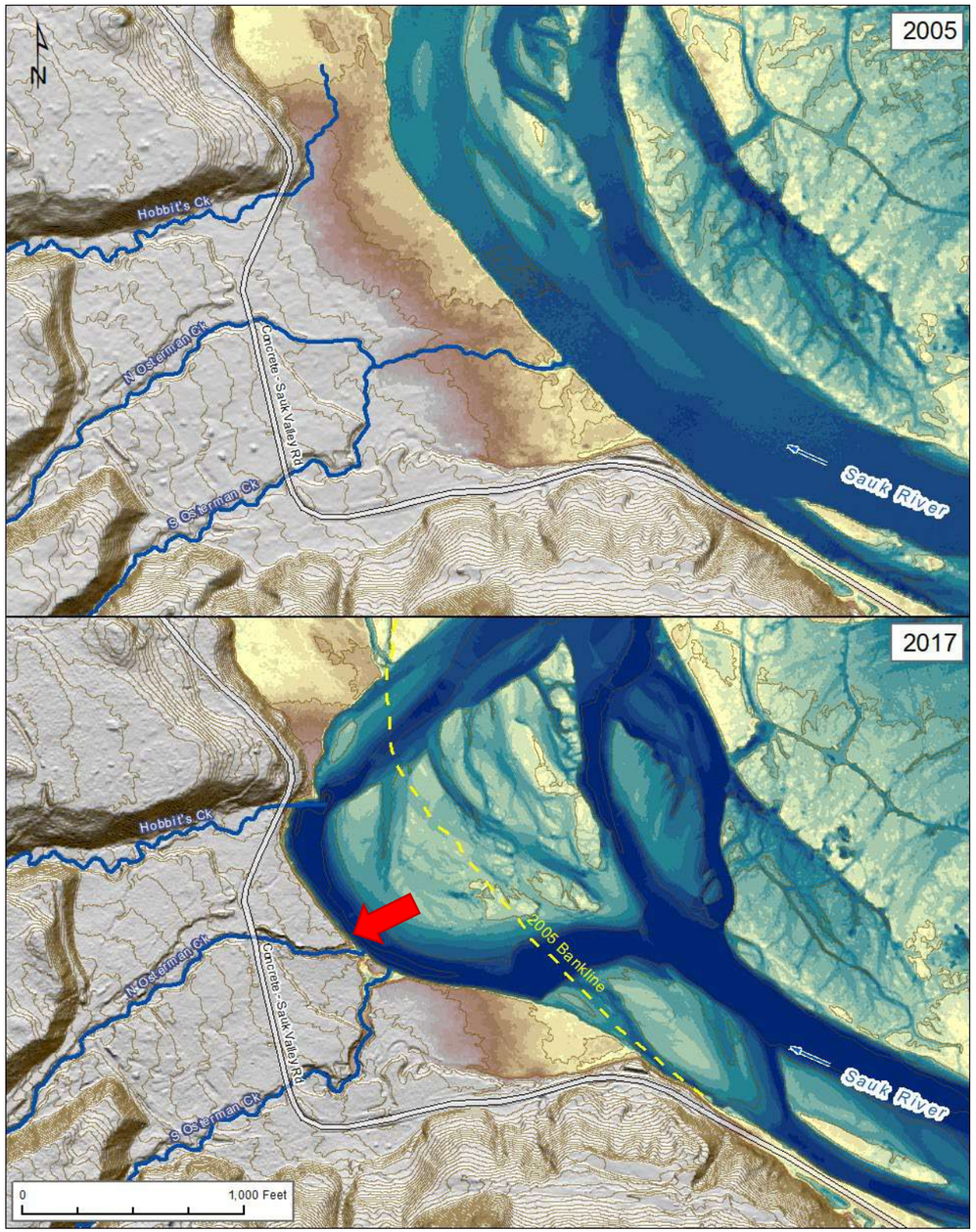


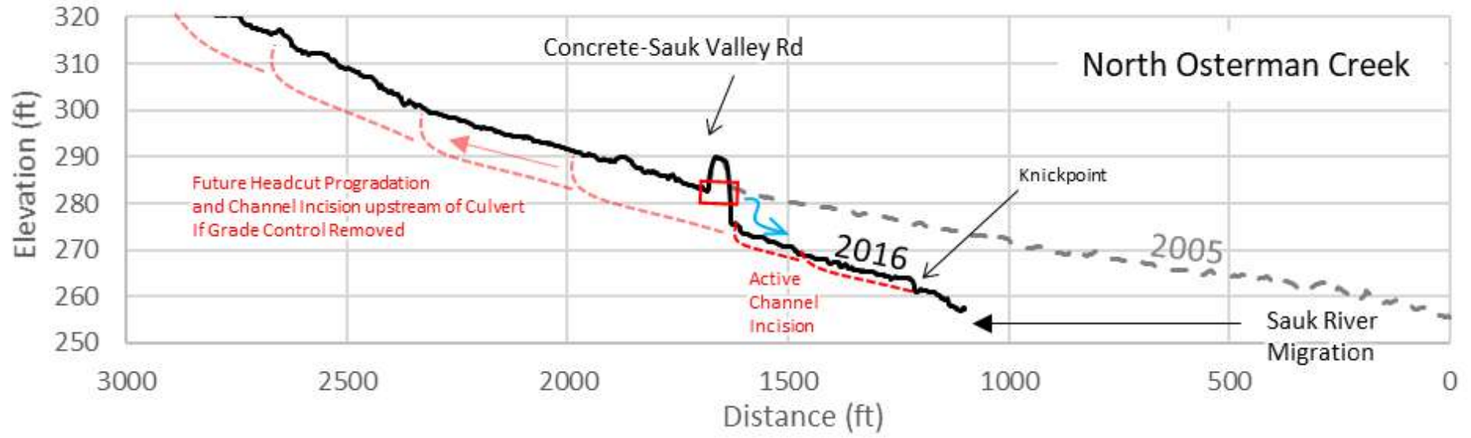
Trib_Name	Area_SqMi	AvgP_in
Hobbit	0.9	84.5
N Osterman	1.0	91.5
S Osterman	1.4	86.7


2005
N
Hobbit's Ck
N Ostrman Ck
Concrete - Sauk Valley Rd
S Ostrman Ck
Sauk River
2017
Hobbit's Ck
N Ostrman Ck
Concrete - Sauk Valley Rd
2005 Bankline
S Ostrman Ck
Sauk River
0
1,000 Feet

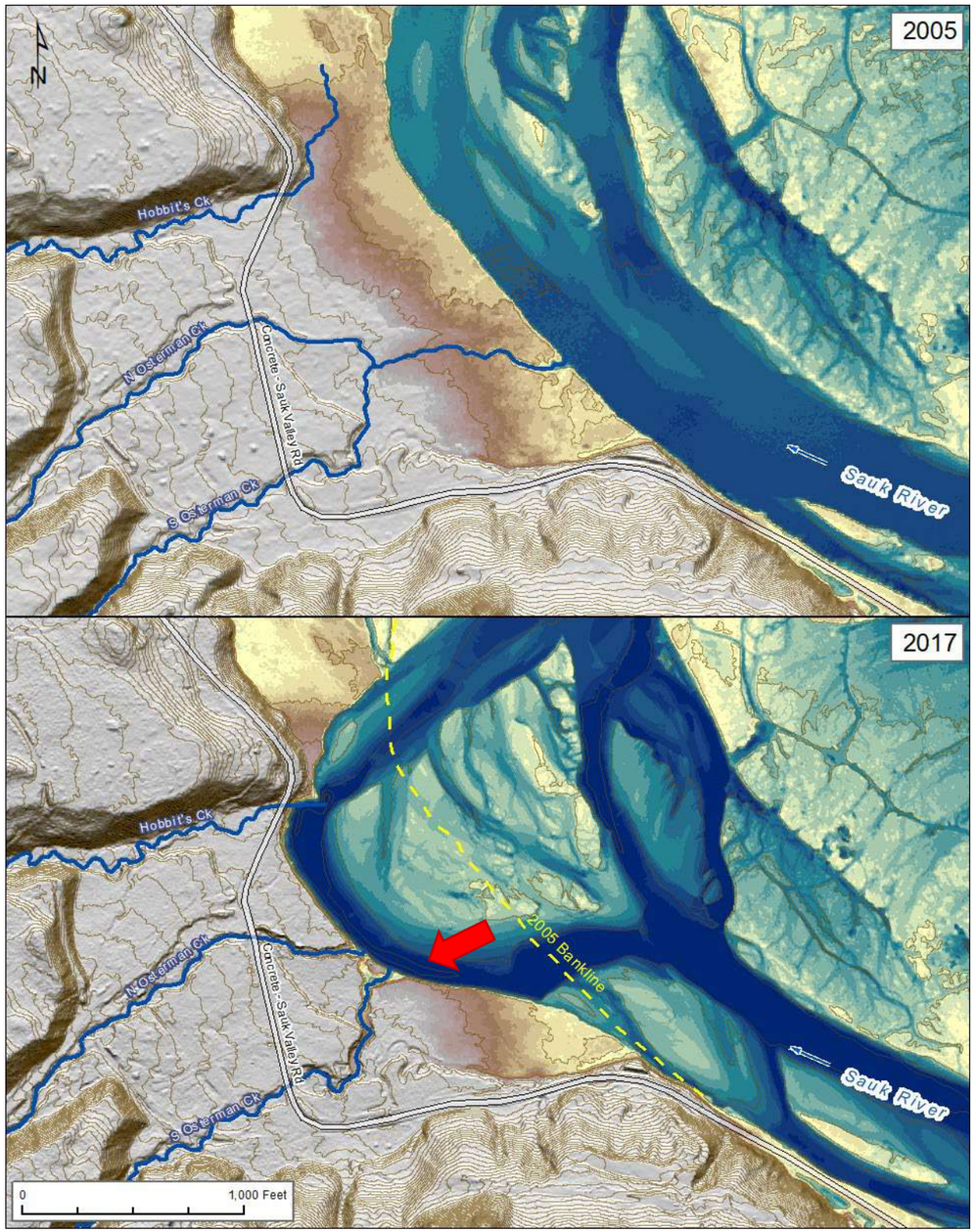

Hobitt's Creek
Elevation (ft)
320
310
300
290
280
270
260
250
Concrete-Sauk Valley Rd
Bridge (Pvt)
2016
2005
Future Headcut Progradation
and Channel Incision upstream of Culvert
If Grade Control Removed
Sauk River
Migration
3000
2500
2000
1500
1000
500
0
Distance (ft)

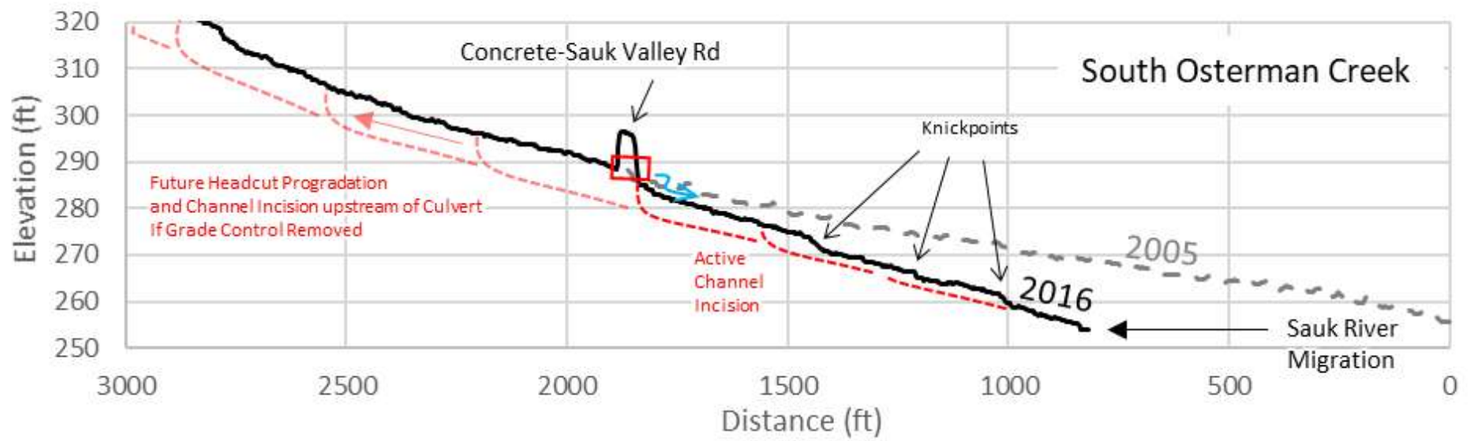






Culvert (upstream)





Culvert (downstream)

Approach to Wild and Scenic designation

- Consult with the Forest Service early and often
- Gather stakeholder input through-out
- Evaluate options
  - Relocate infrastructure out of harm's way
  - Work with natural processes not against
  - Mimic natural processes and aesthetic

Conceptual Design Recommendations

- Design bank protection to withstand main channel (severe) hydraulics
- Grade control in all tributary streams to prevent incision
- Evaluate upstream/downstream impacts of mainstem actions

Conceptual Design Themes

- Alternative 1 – Re-locate road outside of low risk erosion zone
- Alternative 2 – Re-locate road outside of high risk erosion zone
- Alternative 3 – Keep road in current location

Alternative 3

(1) Relocate road to abandoned RR grade and construct 3 new stream crossings
(2) No Sauk River bank treatments
(3) Remove existing stream crossings (where feasible)
(4) Roughened channel with grade control in tribs
(5) Provide alternate access to local residents

Alternative 2

(1) Relocate road out of highest erosion hazard zone
(2) Armor eroding bank with complex log revetment
(3) Replace existing stream crossings
(5) Roughened channel with grade control in tribs.

1,454,000

1,456,000

628,000

526,000

Alternative 1

(1) Leave road within existing ROW
(2) Armor eroding bank with complex log revetment
(3) Array of ELJS to create energy dissapation zone
(4) Replace existing stream crossings
(5) Roughened channel with grade control in tribs.

N

Concrete-Sauk Valley Rd

Hobbit's Ck

N Osterman Ck

S Osterman Ck

Sauk River

1

2

3

4

5

Relative Eleation (feet)
20
15
10
5
0
-5

0 500 1,000 ft

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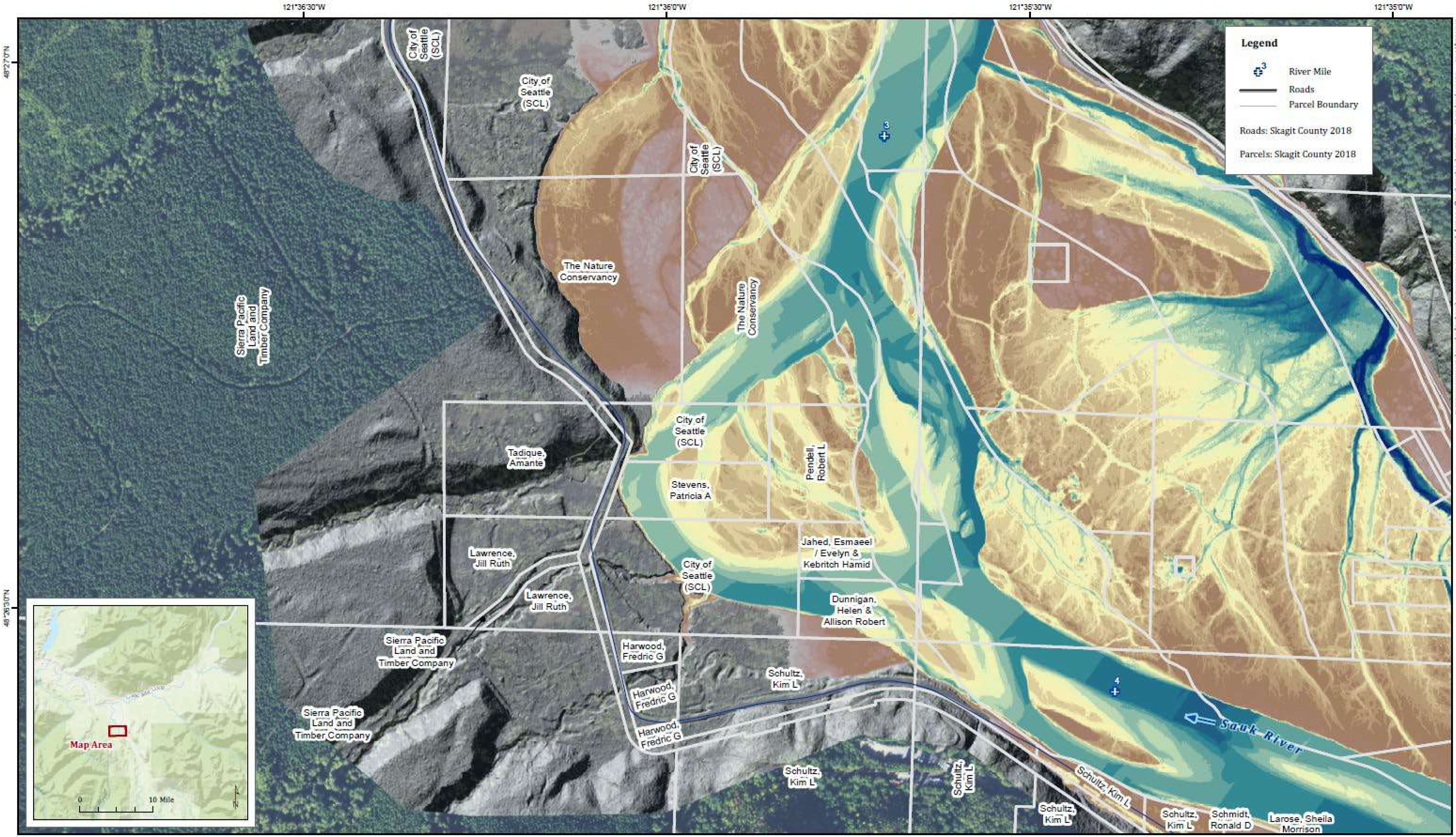
Additional Slides



Concrete-Sauk Valley Road Bank Stabilization Milepost 13

0 500 1,000 1,500 2,000 Feet

Lambert conformal conic projection, NAD 1983
State Plane Coordinate System (WA North Zone)
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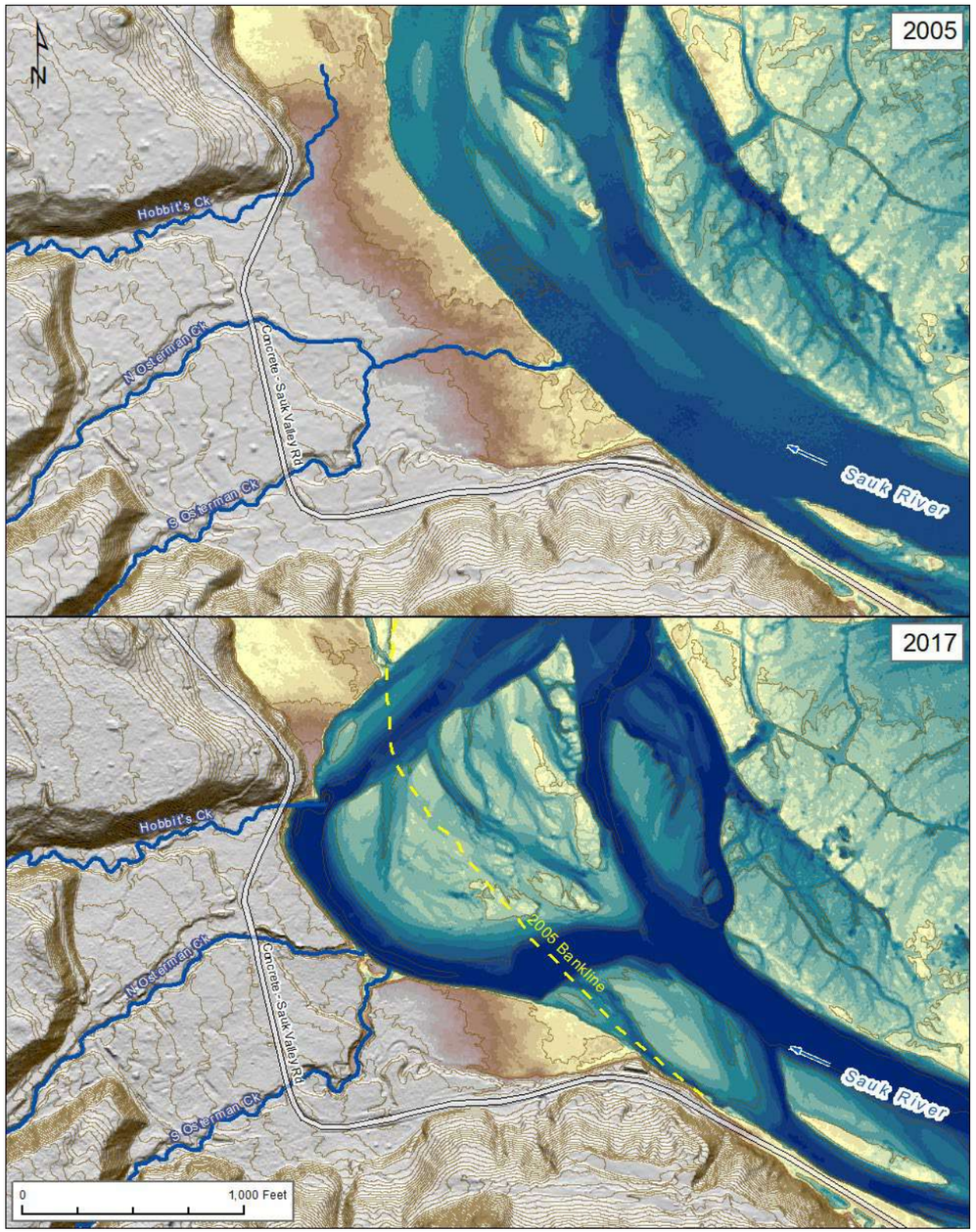
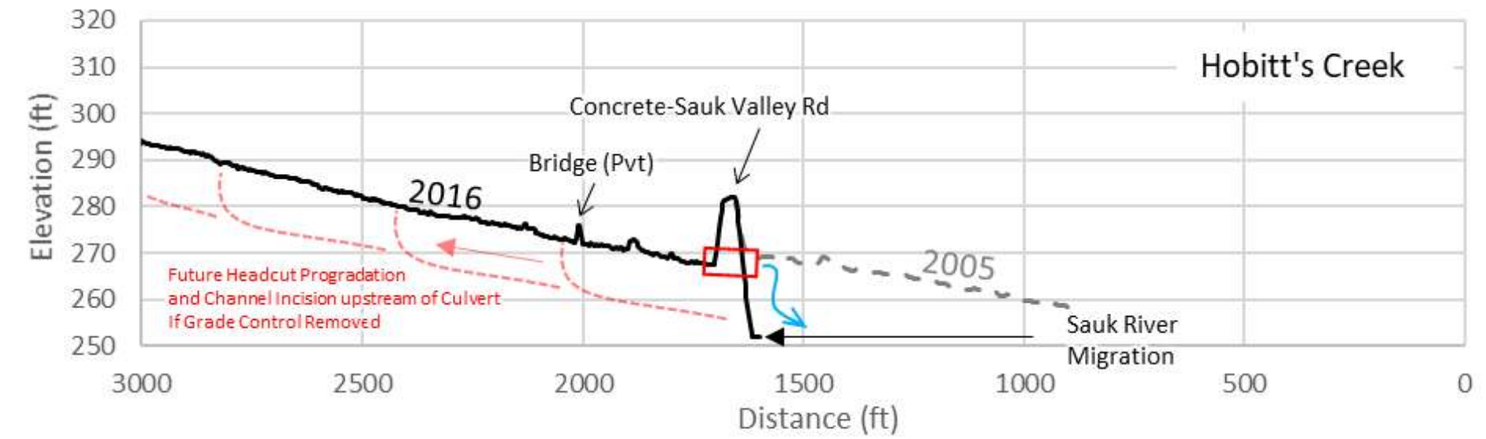
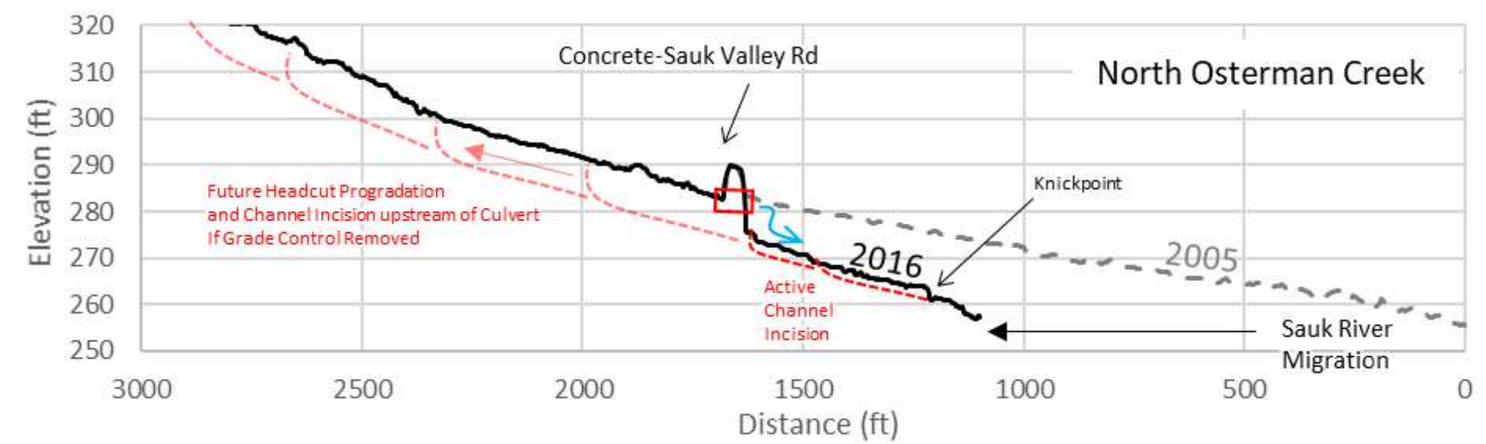
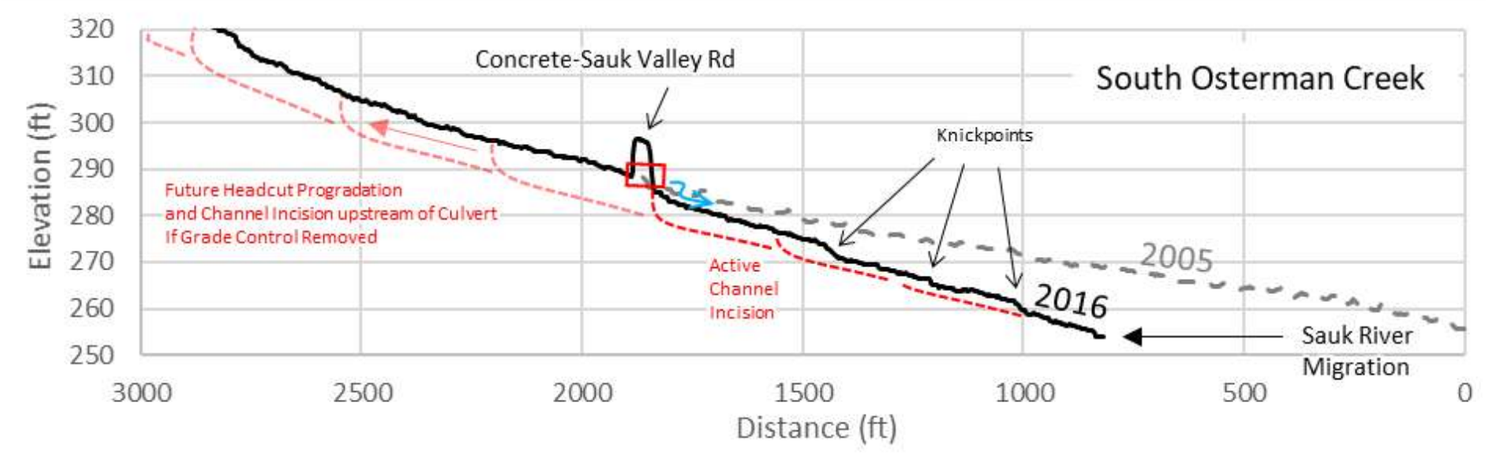
Natural Systems Design

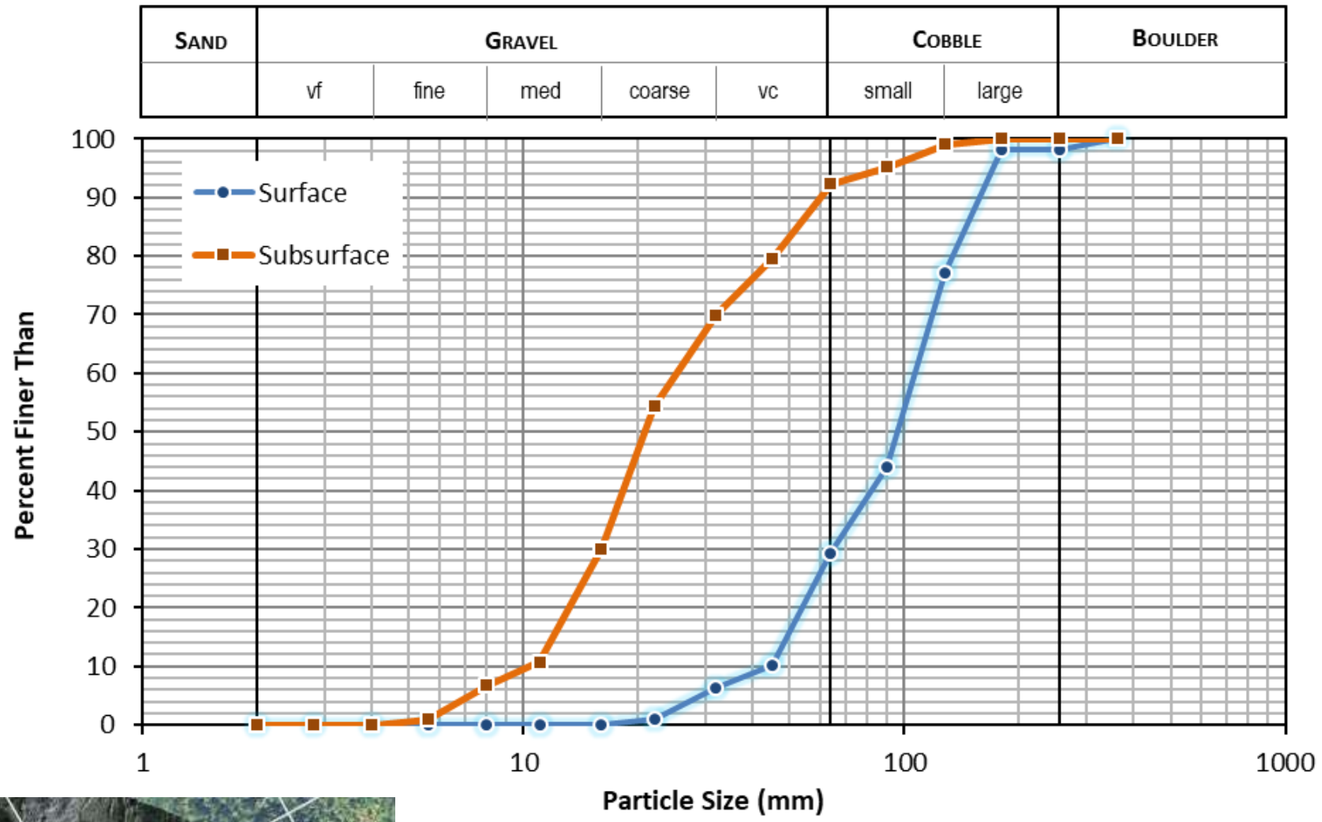

2005
N
Hobbit's Ck
N Osterman Ck
Concrete - Sauk Valley Rd
S Osterman Ck
Sauk River
2017
Hobbit's Ck
N Osterman Ck
Concrete - Sauk Valley Rd
2005 Bankline
S Osterman Ck
Sauk River
0
1,000 Feet

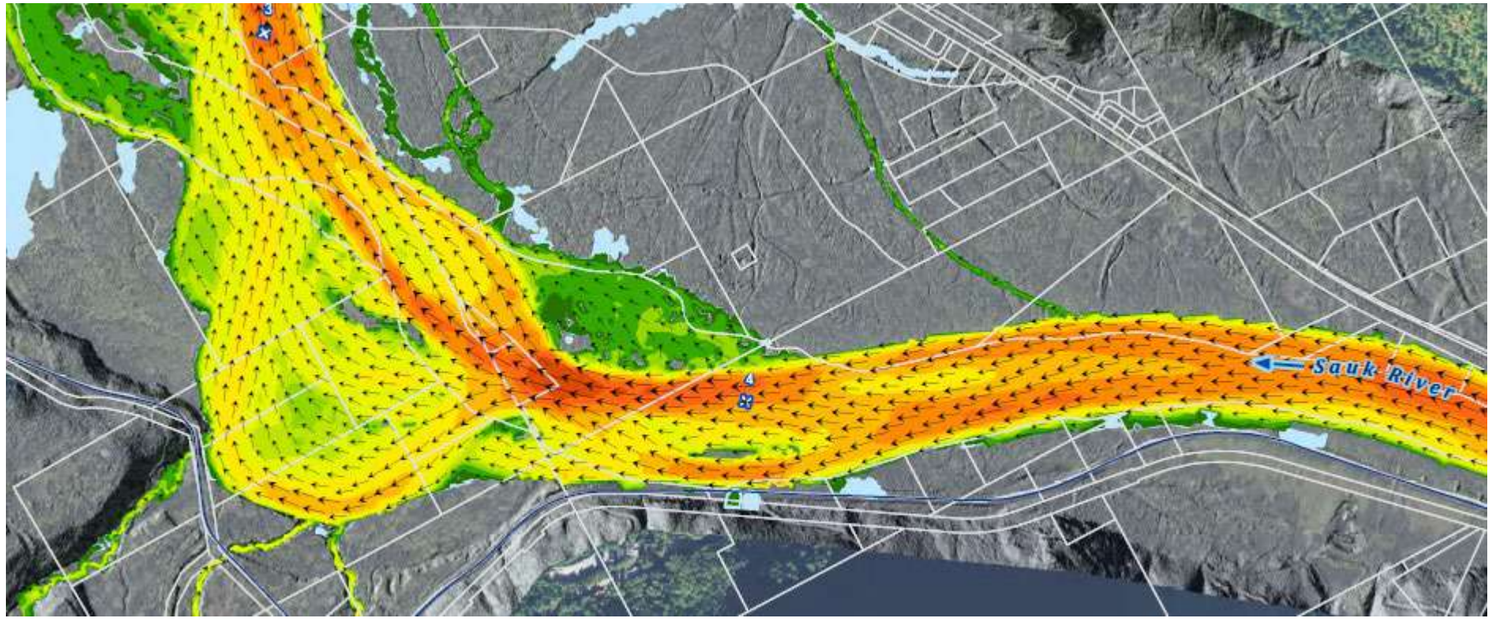

Hobitt's Creek
Elevation (ft)
320
310
300
290
280
270
260
250
Concrete-Sauk Valley Rd
Bridge (Pvt)
2016
2005
Future Headcut Progradation
and Channel Incision upstream of Culvert
If Grade Control Removed
Sauk River
Migration
3000
2500
2000
1500
1000
500
0
Distance (ft)


North Osterman Creek
Elevation (ft)
320
310
300
290
280
270
260
250
Concrete-Sauk Valley Rd
Future Headcut Progradation
and Channel Incision upstream of Culvert
If Grade Control Removed
Knickpoint
2016
2005
Active
Channel
Incision
Sauk River
Migration
3000
2500
2000
1500
1000
500
0
Distance (ft)

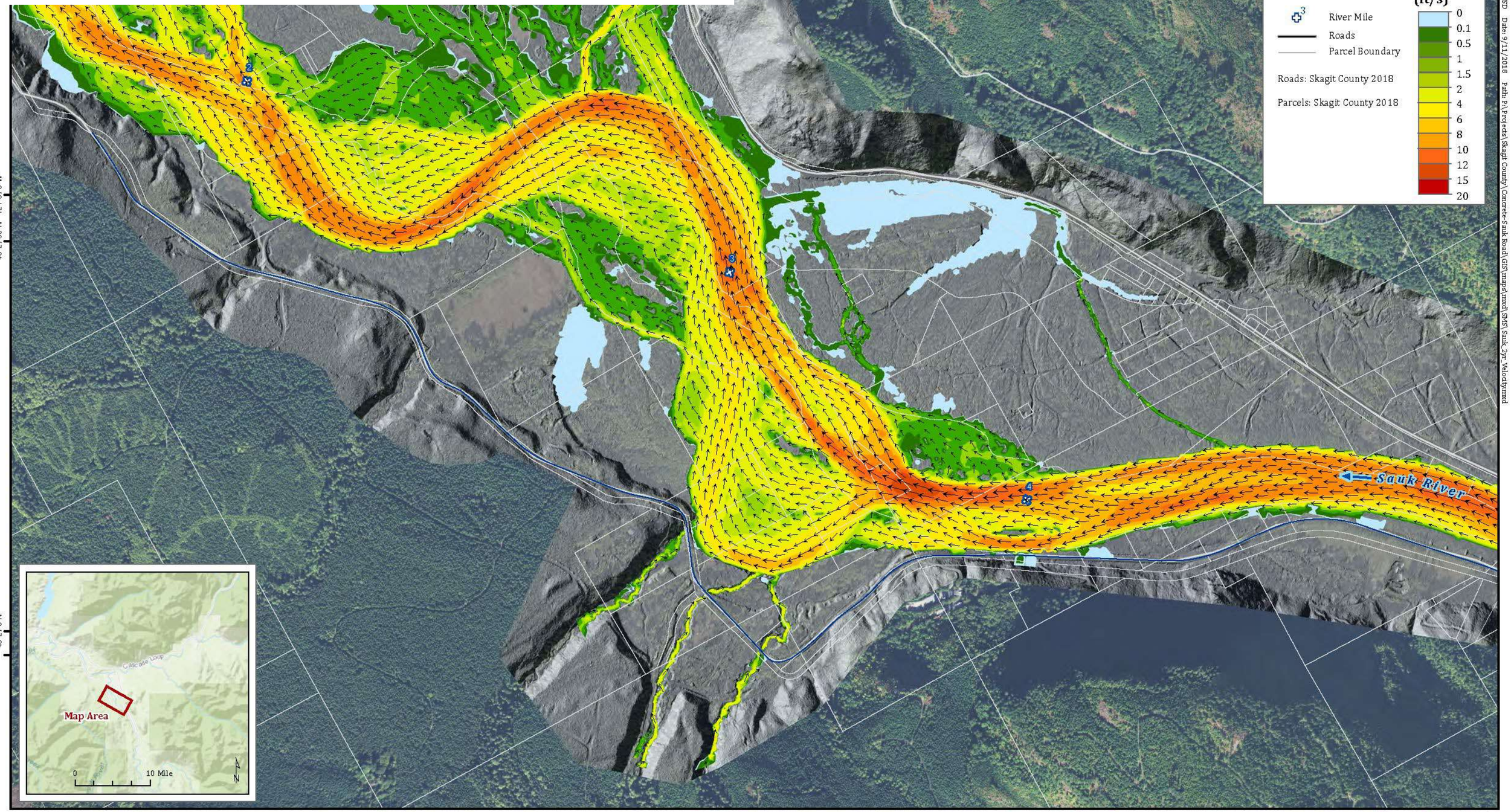

South Osterman Creek
Elevation (ft)
320
310
300
290
280
270
260
250
Concrete-Sauk Valley Rd
Knickpoints
Future Headcut Progradation
and Channel Incision upstream of Culvert
If Grade Control Removed
Active
Channel
Incision
2005
2016
Sauk River
Migration
3000
2500
2000
1500
1000
500
0
Distance (ft)

Sediment Mobility





Sediment Mobility and Erosion



Concrete-Sauk Valley Road Bank Stabilization Milepost 13

2-Year Flow (38,378 cfs)

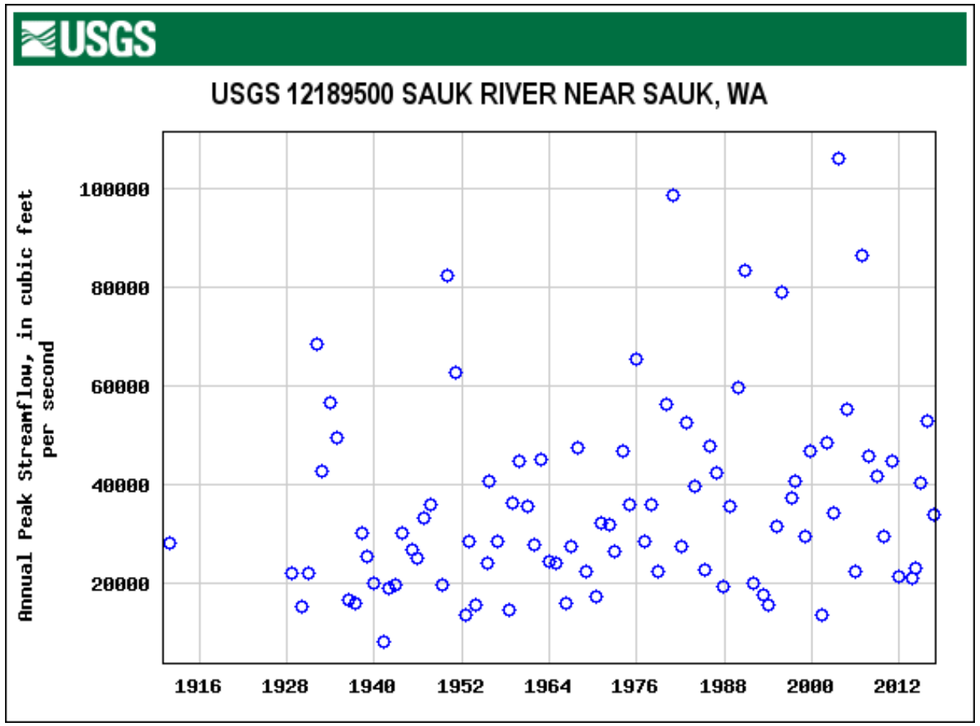
Hydronia RiverFlow-2D Plus GPU Hydraulic Model output

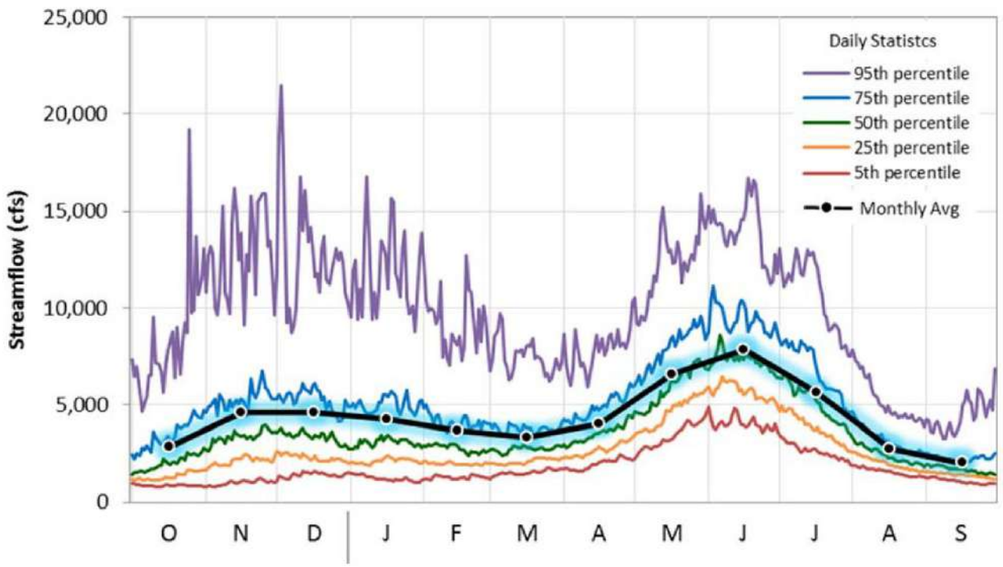
0 500 1,000 1,500 2,000 Feet

Lambert conformal conic projection, NAD 1983
State Plane Coordinate System (WA North Zone)
- Topography: 2016 LIDAR DEM (PSLC) and 2018 topographic survey.

Natural Systems Design

Hydraulic Analysis

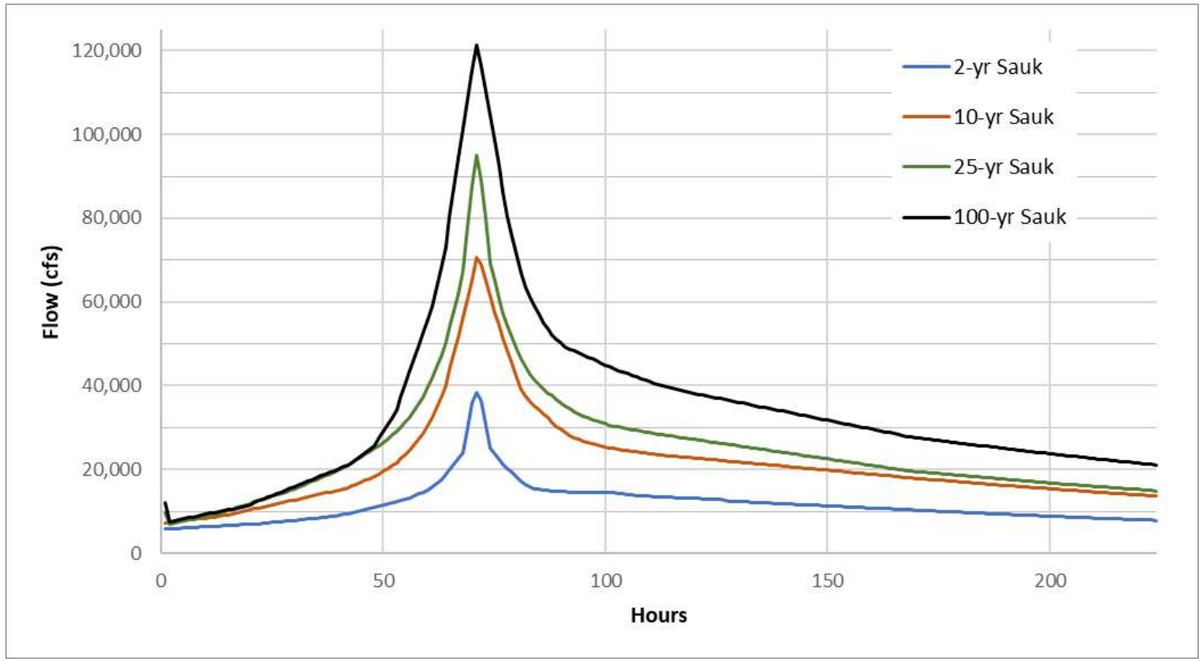




Peak flow and daily statistics at USGS gage #12189500

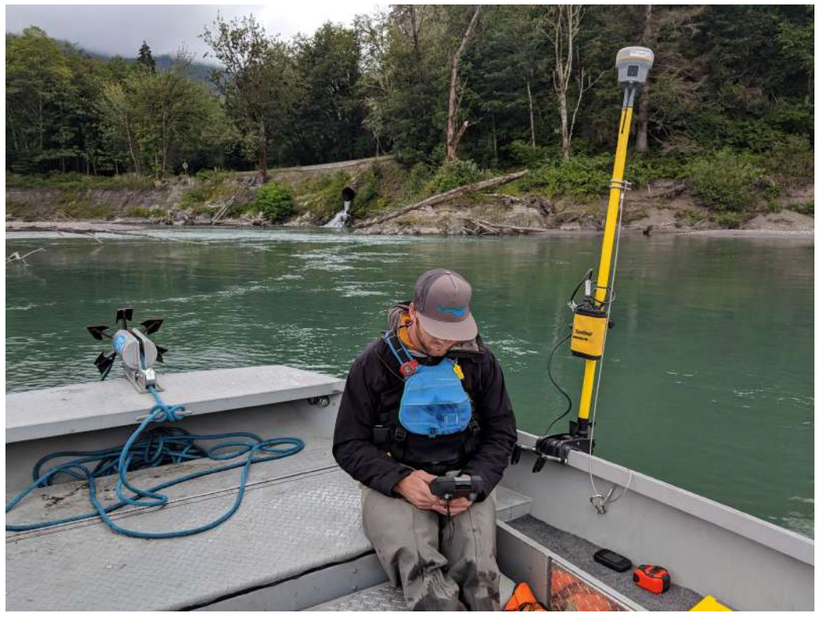
Peak Flow Analysis/Input Hydrograph

- Flow inputs are steady state flow peaks from CWMS HEC-RAS model
- Tributary inflows derived from USGS regional regression based on Drainage Area and Precip



	Q100 (cfs)
USACE CWMS RAS model	121,190
USGS Gage (Bull 17b)	108,240
FEMA FIS	94,000

Hydraulic Analysis



Surface Model Development

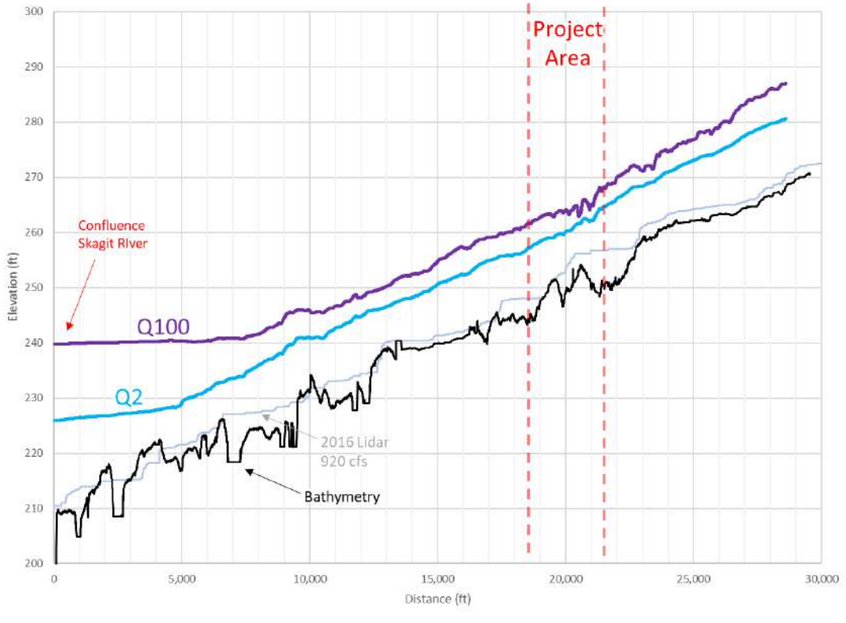
- 2018 Bathymetric survey
- 2016 Lidar representing floodplain
- 2017 Green Lidar downstream of project area

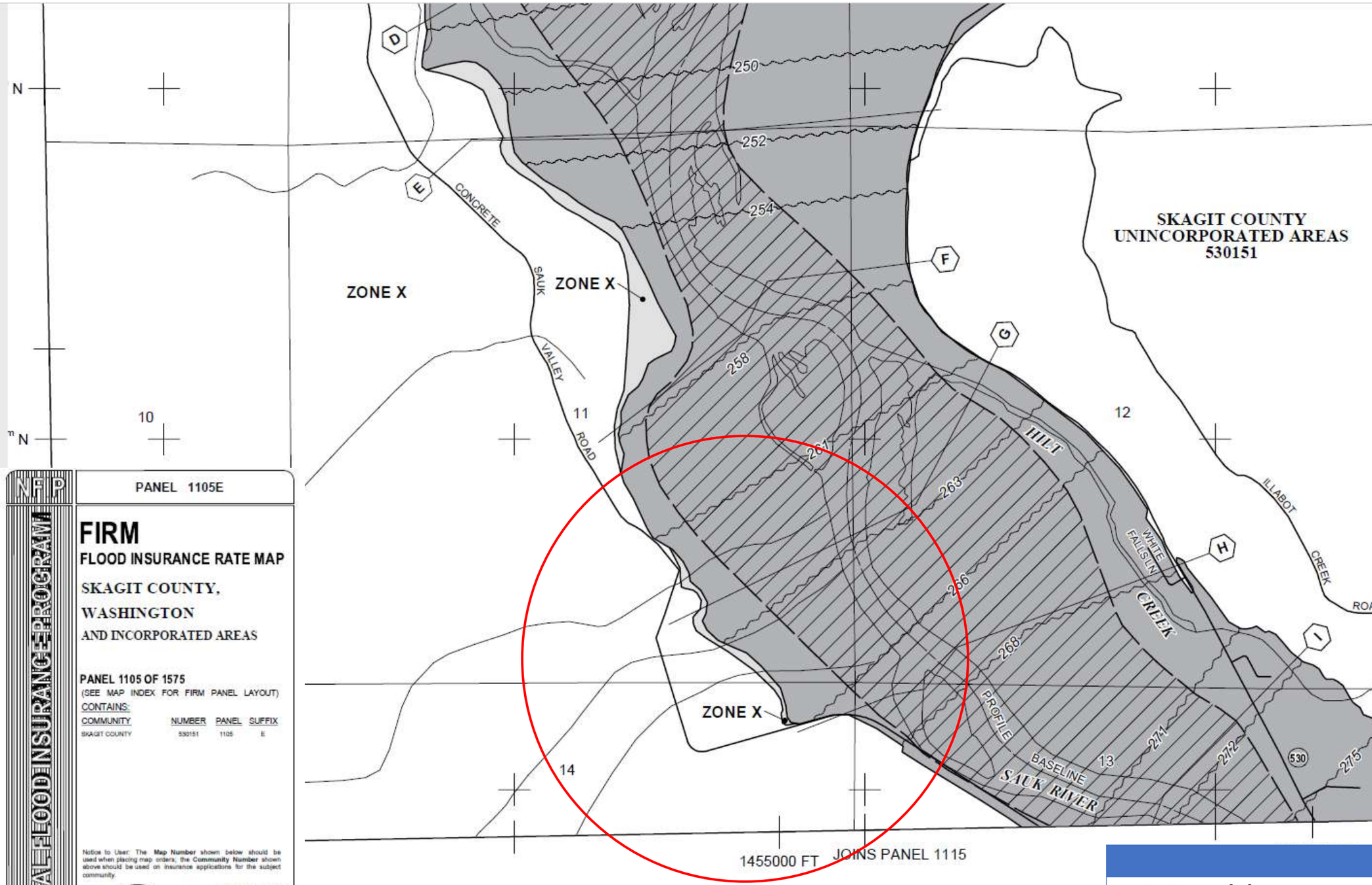
Surface Roughness

- Applied roughness coefficient (Manning's *n*) calibrated from Skagit Barnaby model
- Validated with comparison of to WSE in 2016 lidar data

Downstream Boundary Condition

- Max WSEL from CWMS HEC-RAS model





LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A No Base Flood Elevations determined.

ZONE AE Base Flood Elevations determined.

ZONE AH Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.

ZONE AO Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.

ZONE AR Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.

ZONE A99 Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.

ZONE V Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.

ZONE VE Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

Floodplain boundary

Floodway boundary

Zone D boundary

CBRS and OPA boundary

Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.

513 — Base Flood Elevation line and value; elevation in feet*

(EL 987) — Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

A — A — Cross section line

23 — 23 — Transect line

97°07'30", 32°22'30" — Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)

4475000mN — 1000-meter Universal Transverse Mercator grid ticks, zone 10

6000000 FT — 5000-foot grid ticks: Washington State Plane coordinate system, north zone (FIPSZONE 4601), Lambert Conformal Conic

DX5510 — Bench mark (see explanation in Notes to Users section of this FIRM panel)

M1.5 — River Mile

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 1105E

FIRM

FLOOD INSURANCE RATE MAP

SKAGIT COUNTY, WASHINGTON AND INCORPORATED AREAS

PANEL 1105 OF 1575

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
SKAGIT COUNTY	530151	1105	E

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

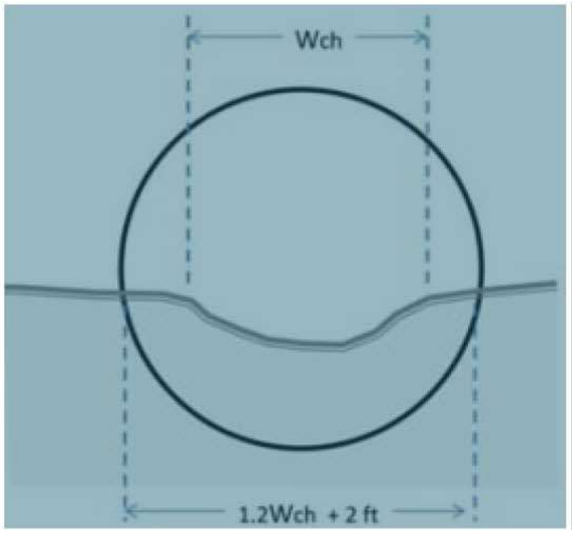
MAP NUMBER
53057C1105E

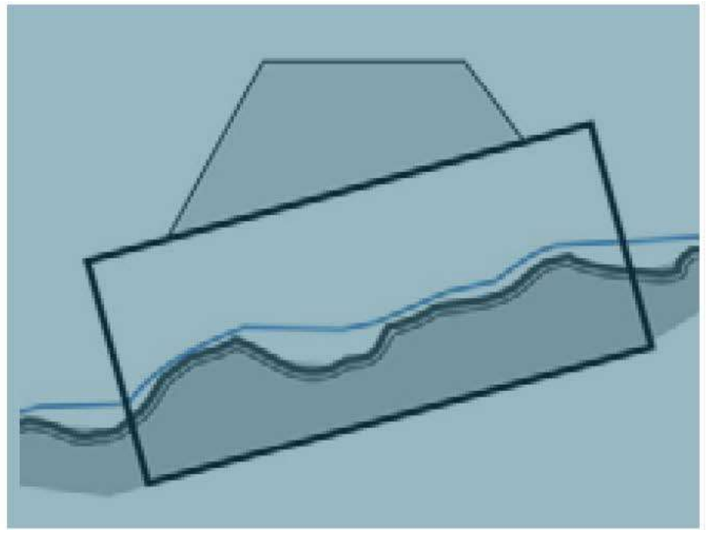
EFFECTIVE DATE

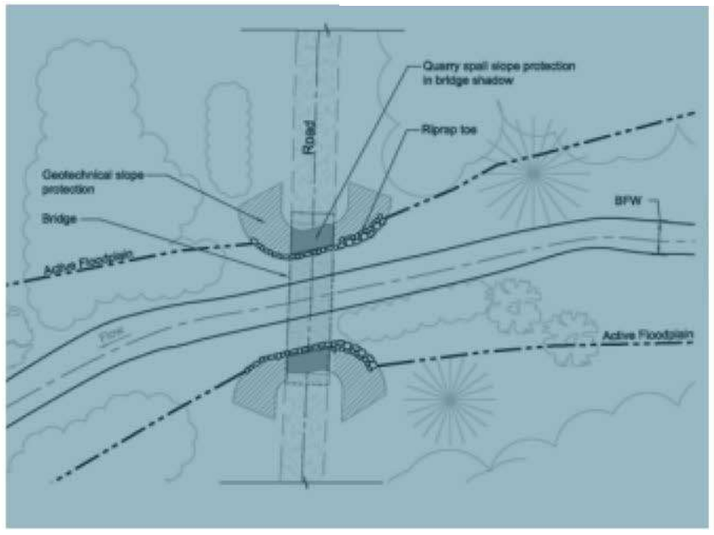
Federal Emergency Management Agency

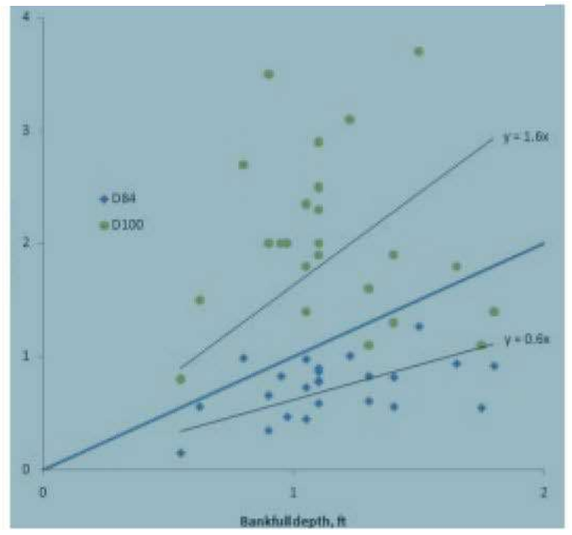
	Q100 (cfs)
USACE model	121,190
USGS Gage (Bull 17b)	108,240
FEMA	94,000

Culvert Sizing







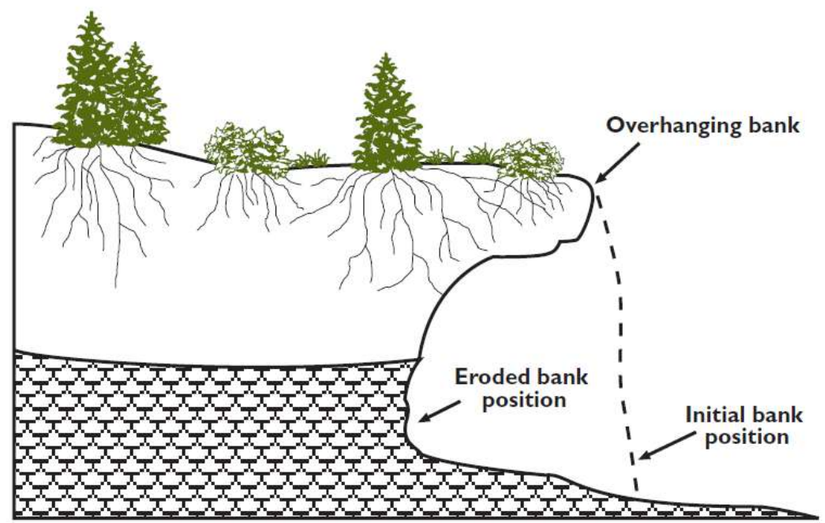


Culvert	Existing Culvert Size (ft)	Measured Channel Width* (ft)	Minimum opening width per WDFW (ft)	Calculated Channel Width** (ft)	Minimum culvert opening per WDFW** (ft)
Hobbit Creek	6.5’ CMP	16	21	13	18
N Osterman Creek	5’ RCP	15	20	14	18
S Osterman Creek	5’ RCP	16	21	16	21

* based on 2016 LiDAR and 2018 survey

**using equation C.1 (Barnard et al., 2013)

Sediment Mobility and Erosion



WDFW (2002)

Sediment mobilized when applied shear stress exceeds critical shear stress ($\tau_c > \tau_0$)

D50 (surface) = 100 mm (4 in)
D50 (subsurface) = 22 mm (<1 in)

Bank material includes high sand content and is Generally more erodible than bed

Mobilization of armor layer (gravel/cobble) initiates Toe Erosion

No erosion on left bank Nov 2017 at 60,000 cfs (Q10)
~ 100 ft erosion on next meander bend downstream

Model output in agreement with observed decline in erosion rates associated with cutoff development

Future risk of continued erosion on terrace is HIGH and will accelerate when channel shifts dominant flow back into meander bend

Existing Conditions Summary

- Westward channel migration slowing and becoming “self-limiting”

- Right channel presently conveys majority of flow

- Roadway is within the channel migration zone
  - Portion within high risk zone
  - Majority within low risk zone

- Roadway is outside the floodplain within the immediate project area