2022 Fish Passage and Stream Restoration Design Training

Module 9: Site and Reach Assessments and Reference Reaches

Garrett Jackson and Cygnia Rapp
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Garrett Jackson, L.G.

Hydrology Program Manager
Headquarters Hydraulics
WSDOT

Current duties: Oversees hydrology program support of Chronic Environmental Deficiencies and Fish Passage Programs. Develops Large Wood policy and reviews implementation. Provides technical support to emergency actions. Designs nature-based shoreline stabilization in marine and freshwater. NCHRP panel support.

Background & Experience: Garrett's experience includes 30 years of theoretical and applied hydrology and geomorphology throughout the western United States and overseas. His work includes stream restoration, geomorphic reach assessments, streambank stabilization, wetland mitigation, geologic hazard evaluation, sediment transport studies, erosion control, hydrologic and hydraulic modeling. He has designed numerous streambank stabilization and stream restoration projects. Garrett worked in consulting for 16 years before joining WSDOT. During the last 12 years, Garrett has been conducting reach assessments, designing emergency streambank stabilization, designing large wood structures, hydraulic modeling, fluvial geomorphic studies, channel migration analysis, and project management.

Education: B.S., University of Arizona, 1986, Geosciences; M.S., 1990, University of Arizona, Geomorphology; Certificate in Stream Restoration, Portland State University, 2007.

Personal interests: Garrett is married and has a large cat, lives in Seattle, and loves backcountry skiing, mountaineering, kayaking, and sport climbing, playing Brazilian music, and singing sea shanties.

Cygnia Rapp, LG

Geomorphologist
HQ Hydraulics, Hydrology Program
WSDOT

Current duties: Provides technical support on fish passage and CED projects, leads research for supporting the design of more resilient infrastructure near gravel-bed streams.

Background & Experience: Cygnia Rapp is a Fluvial Geomorphologist of 20+ years and lead author of state guidelines for assessing channel migration and delineating the channel migration zone. Her current research interest is developing state-of-science guidance and methodology in assessing sediment transport to support the design of resilient infrastructure along and near gravel-bed streams. This research includes the potential for emerging technologies in data collection to enhance the calibration of modern sediment transport models. Cygnia specializes in the evaluation of geomorphic processes as they relate to flooding, channel migration, and the creation and restoration of aquatic habitats.

Education: University of Chicago, BA in Physical Geography, Special Honors, 1994; Arizona State University, MS in Geomorphology, 1997

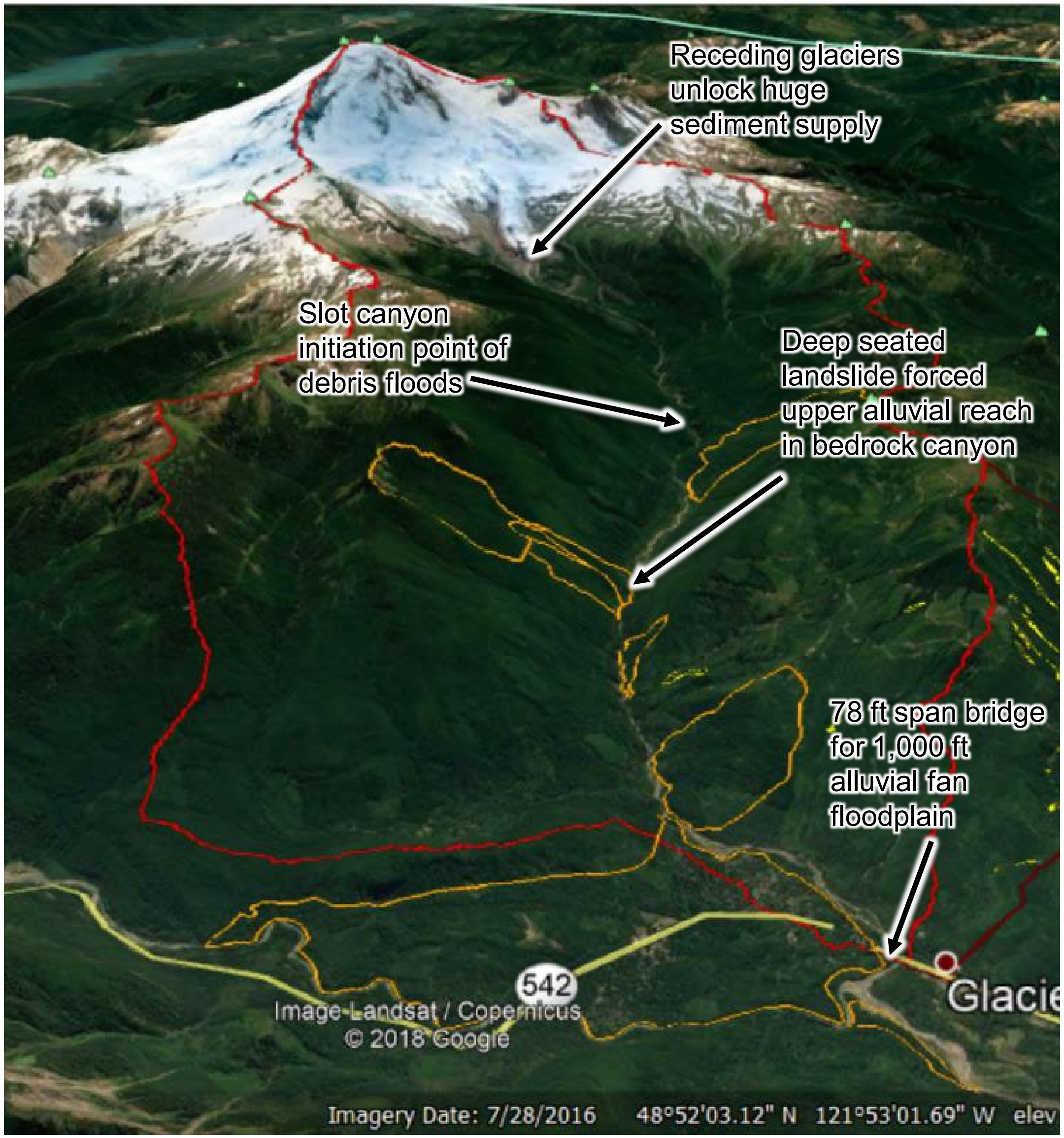
Personal interests: Cygnia lives in Bellingham and enjoys skate skiing, mountain biking, and elk hunting.

Learning Objectives

- Understand why site and reach assessments are important
- Know the basic contents of a site and reach assessment
- Understand how to locate and evaluate reference reaches

Site & Reach Assessments

- Assess the impacts of land use at a specific site for developing appropriate treatments
- Consider different spatial and temporal scales for natural and altered processes



Why conduct Reach Assessment?

Design long-term, successful stream crossings

- Some level of reach assessment is required
- Fish passage/ CED vs fish passage projects require more involved assessment
- Context, impact of watershed/ reach conditions on site
- Risks of stream crossing removal
- Downstream impacts (aggradation, incision)
- Reference reach selection (or reference conditions)
- Basis for design, permitting


2017 clearance 4.6 ft
(2007 was 14.3 ft)

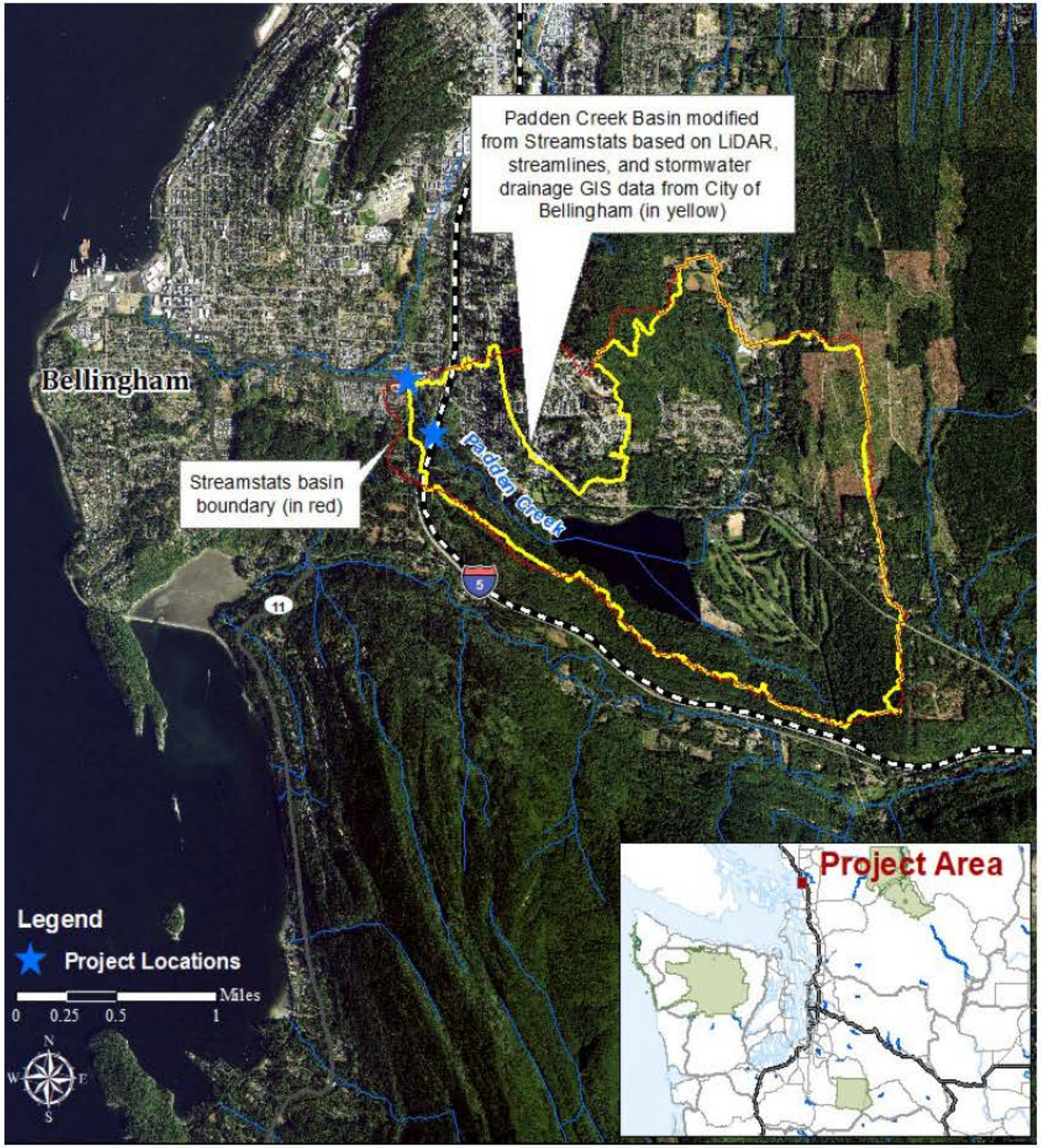

Buried gate


90 degree angle of channel bend
60 degree angle of channel bend
Alluvial fan truncated by 1905 railroad grade
20
Skagit
owned
channel alignment
channel alignment
Creek alluvial fan
Route 20

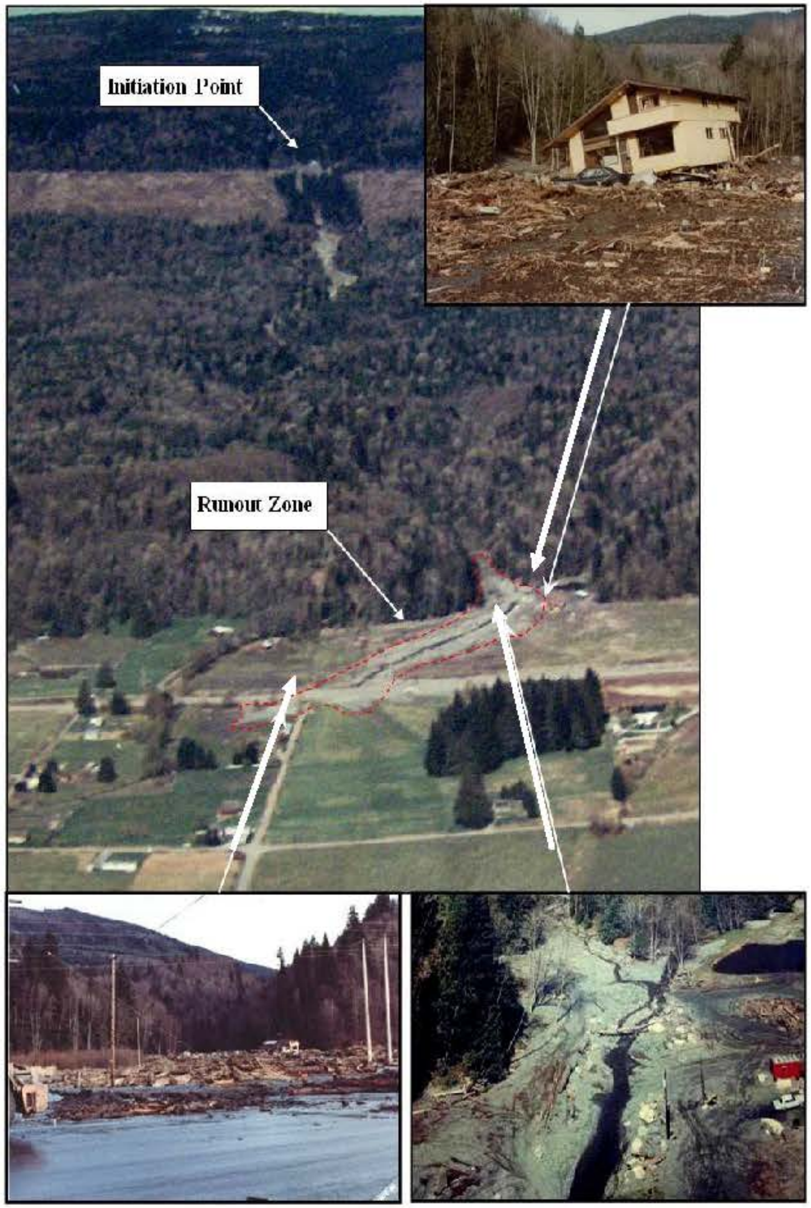
Types of Analyses

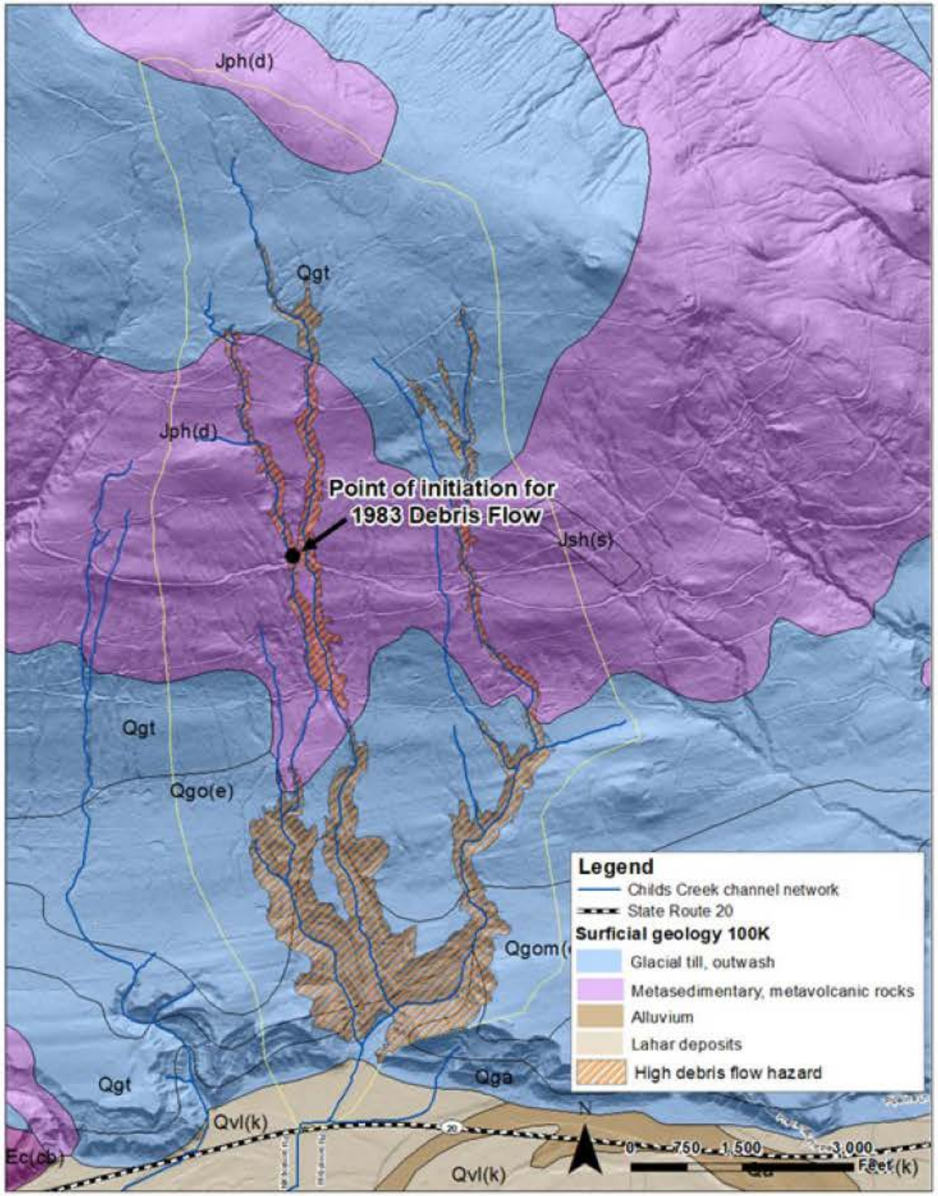
- Land use—impervious surfaces, canopy cover, timber harvest, urbanization
- Hydrology—flood hydrology, peak flow analysis, stormwater drainage effects on channel network
- Geologic—sediment budget, landslide types, locations, frequency
- Geomorphic—trends channel migration (lateral, vertical), floodplain connectivity, bank & channel characteristics, streambed sediment characterization, impacts of WSDOT infrastructure
- Fish habitat—existing conditions, formation factors
- Sediment transport—continuity, aggradation, degradation
- Riparian—existing conditions, potential for large wood recruitment, stream bank strength

Land Use & Hydrology

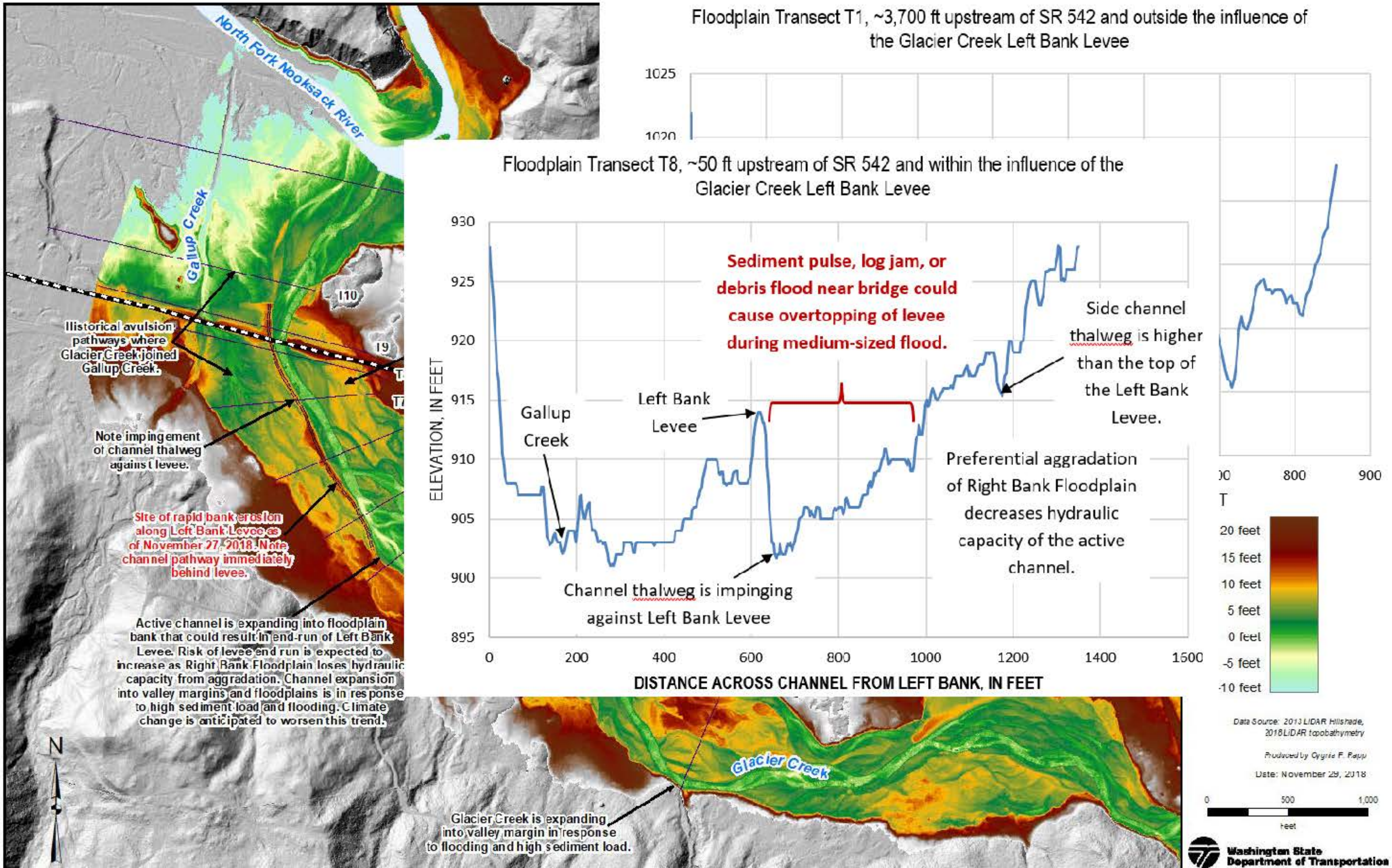


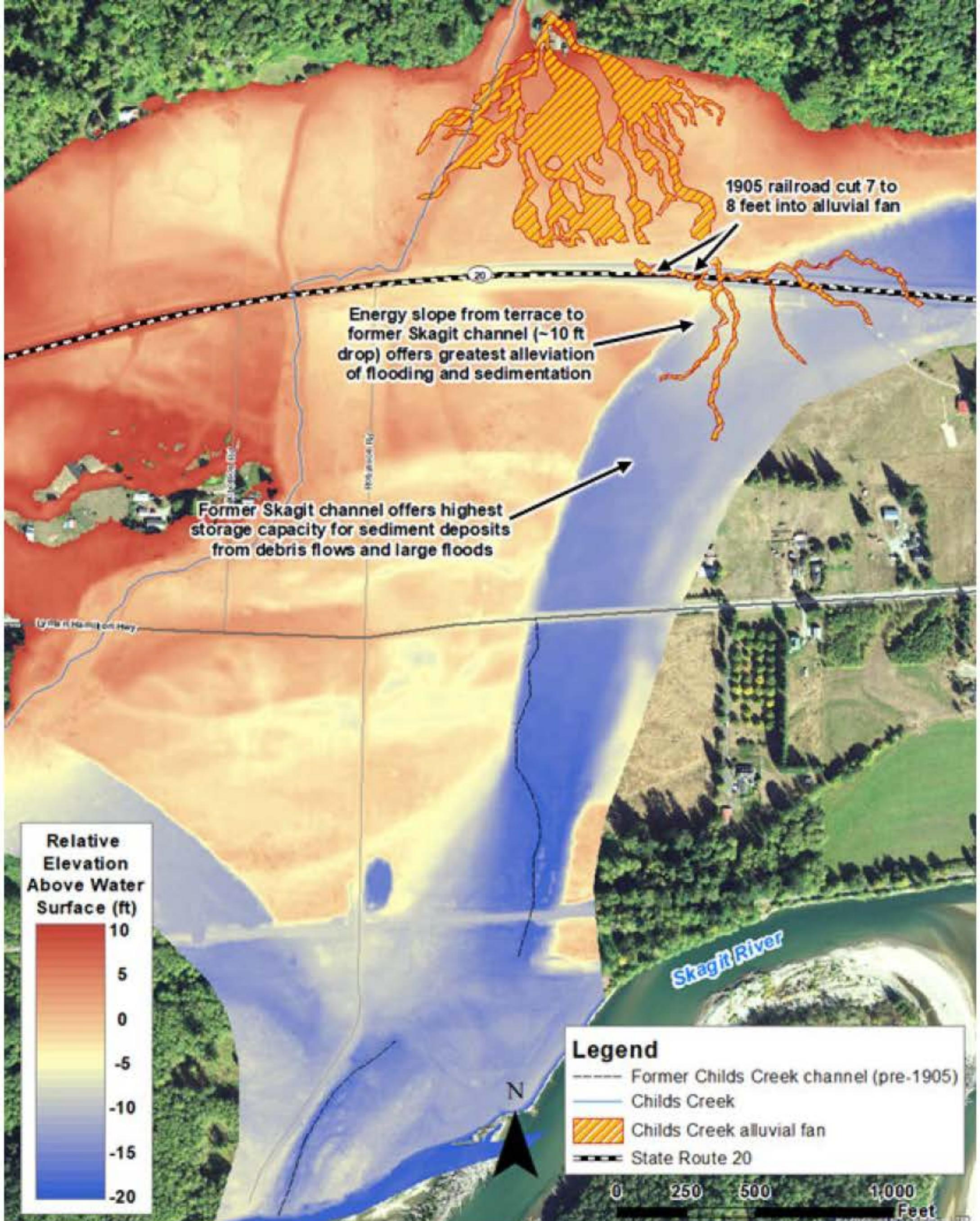
Geology

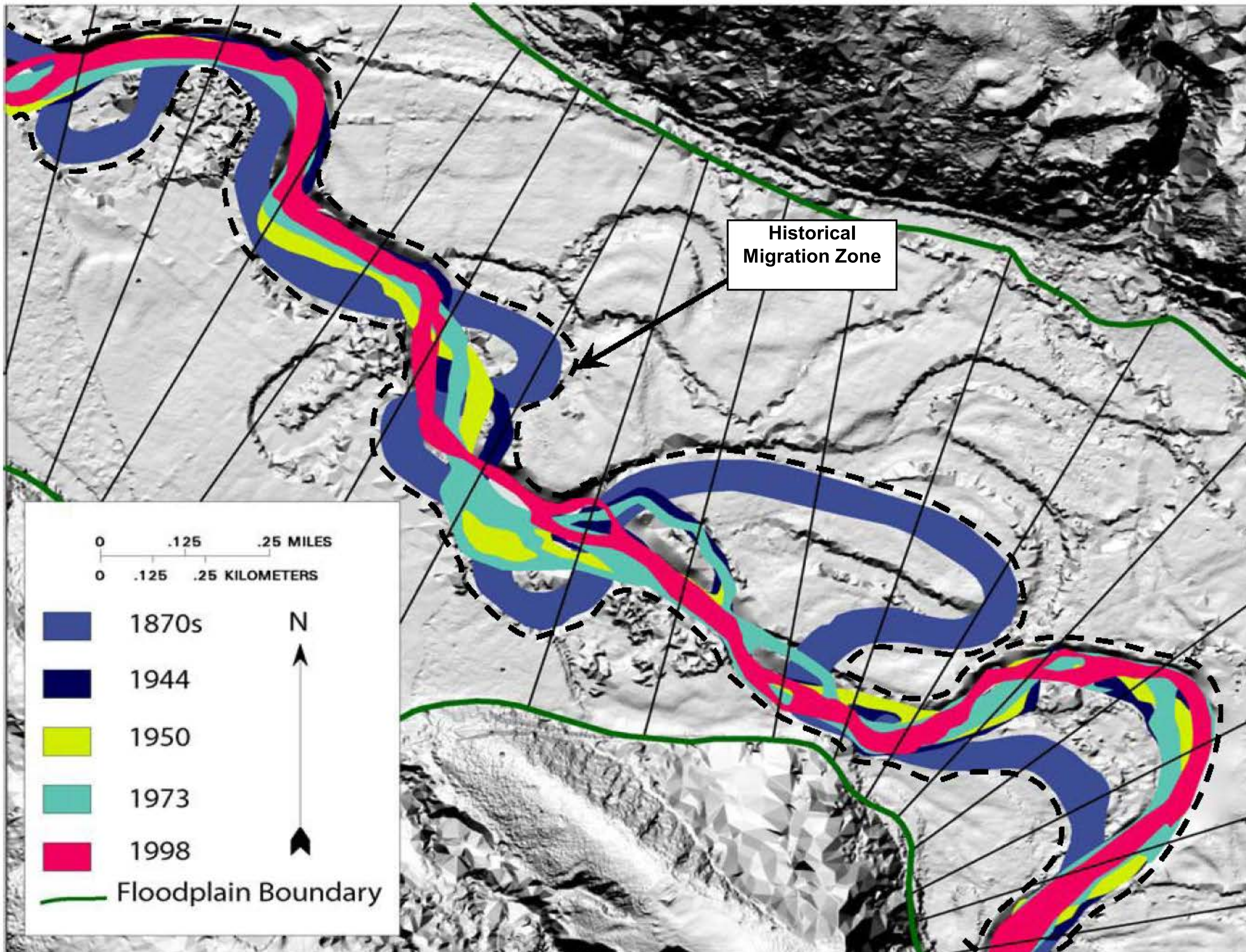

Initiation Point
Runout Zone

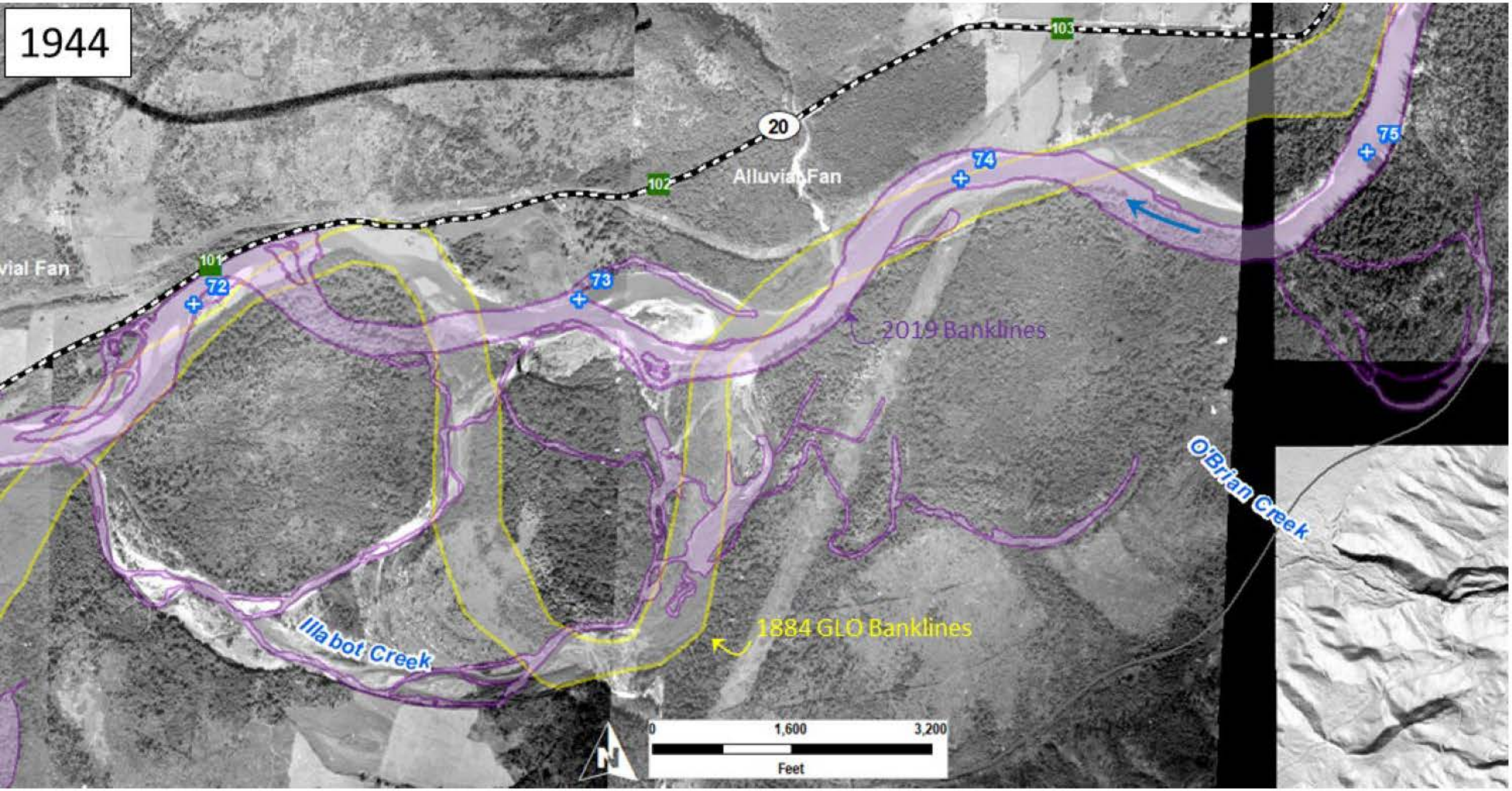

Jph(d)
Qgt
Jph(d)
Point of initiation for
1983 Debris Flow
Jsh(s)
Qgt
Qgo(e)
Qgom
Qgt
Qga
Qvl(k)
Ec(cb)
Qvl(k)
Legend
Childs Creek channel network
State Route 20
Surficial geology 100K
Glacial till, outwash
Metasedimentary, metavolcanic rocks
Alluvium
Lahar deposits
High debris flow hazard
0 750 1,500 3,000
Feet

Geomorphology

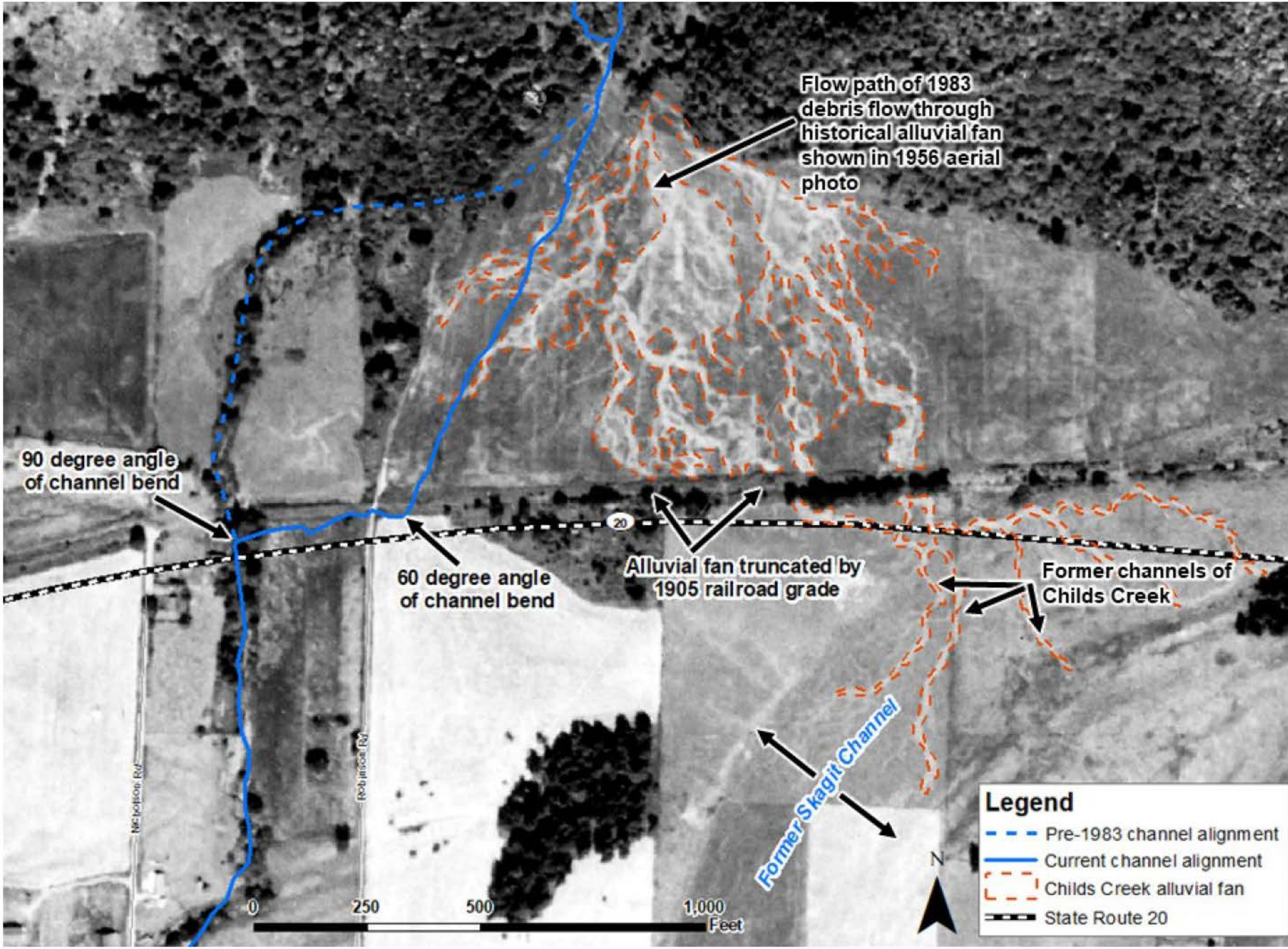



1905 railroad cut 7 to 8 feet into alluvial fan
Energy slope from terrace to former Skagit channel (~10 ft drop) offers greatest alleviation of flooding and sedimentation
Former Skagit channel offers highest storage capacity for sediment deposits from debris flows and large floods
20
Skagit River
Relative Elevation Above Water Surface (ft)
10
5
0
-5
-10
-15
-20
N
Legend
Former Childs Creek channel (pre-1905)
Childs Creek
Childs Creek alluvial fan
State Route 20
0
250
500
1,000
Feet


Historical
Migration Zone
0 .125 .25 MILES
0 .125 .25 KILOMETERS
1870s
1944
1950
1973
1998
Floodplain Boundary
N



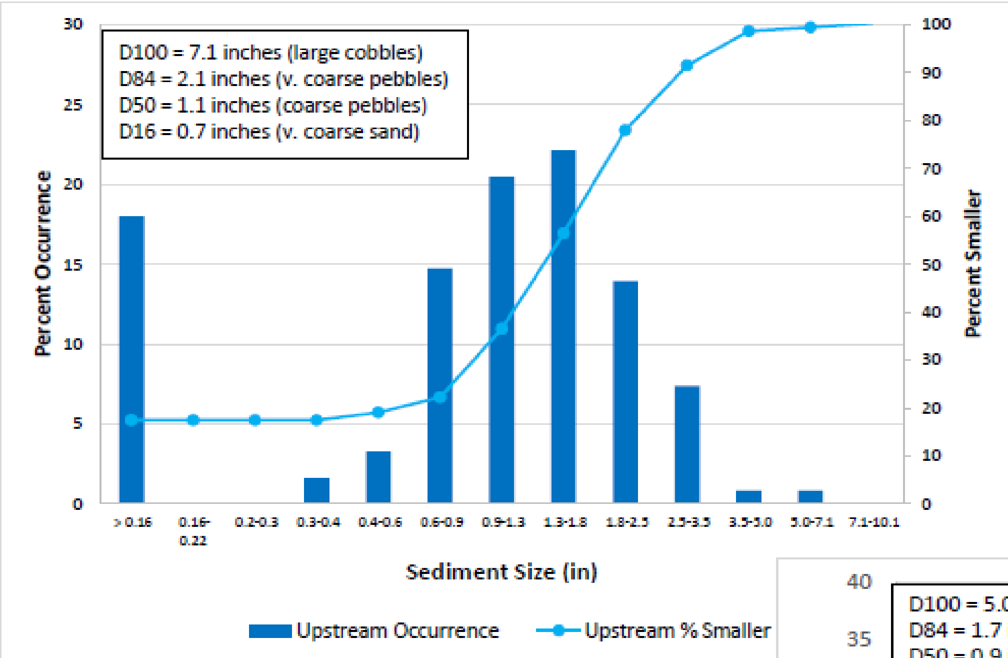
1944
20
101
102
103
72
73
74
75
Alluvial Fan
vial Fan
2019 Banklines
1884 GLO Banklines
Illabot Creek
O'Brian Creek
N
0
1,600
3,200
Feet


Flow path of 1983 debris flow through historical alluvial fan shown in 1956 aerial photo
90 degree angle of channel bend
60 degree angle of channel bend
20
Alluvial fan truncated by 1905 railroad grade
Former channels of Childs Creek
Former Skagit Channel
Nicholson Rd
Robinson Rd
0
250
500
1,000
Feet
N
Legend
Pre-1983 channel alignment
Current channel alignment
Childs Creek alluvial fan
State Route 20

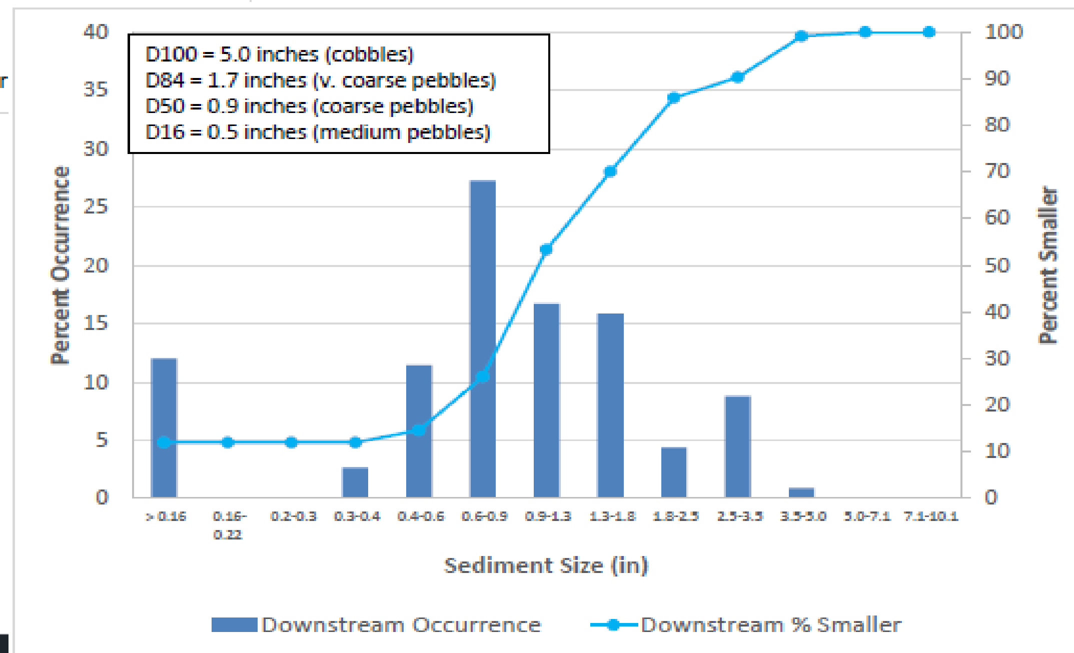
Channel Characteristics

- Channel Bed
  - Type
  - Substrate
  - Fine sediment deposits
- Gravel Bars
  - Type
  - Activity level
  - Side channels
- Bank Erosion
  - Bank erosion factors
  - Bank and vegetation
  - Bank material comp
- Floodplain
  - Entrenchment
  - Terrace material
  - Overbank deposits
- Pool Characteristics
  - Pool forming factors
  - L, W, D
  - Surface substrate
- Bed Characterization*
  - Surface
  - Subsurface

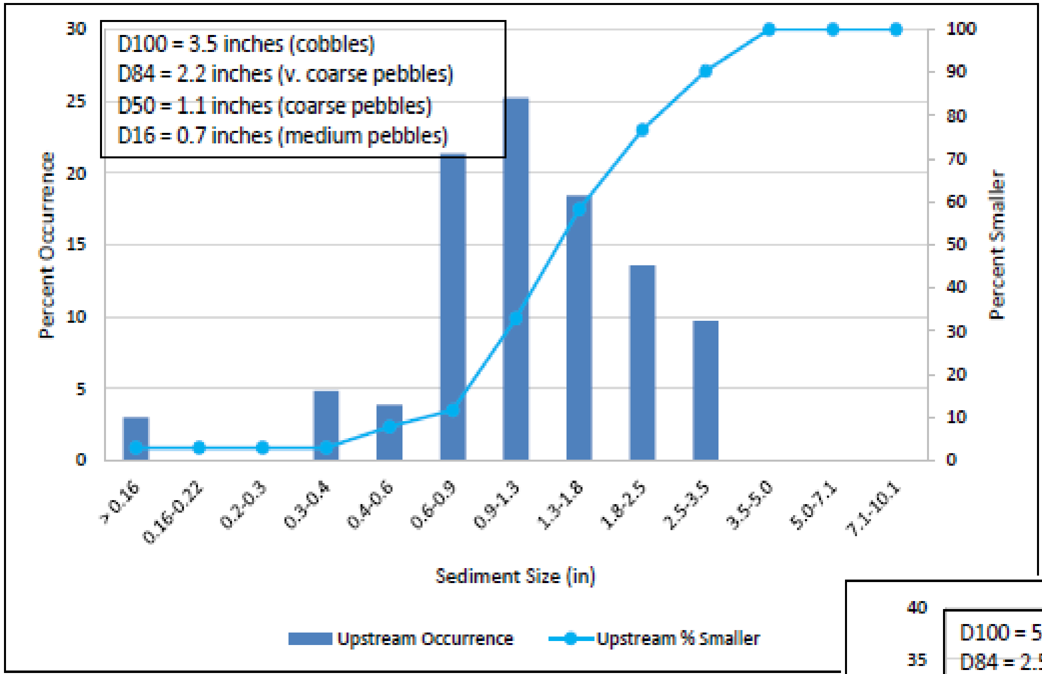
Bed Characterization (Wildcat Creek)



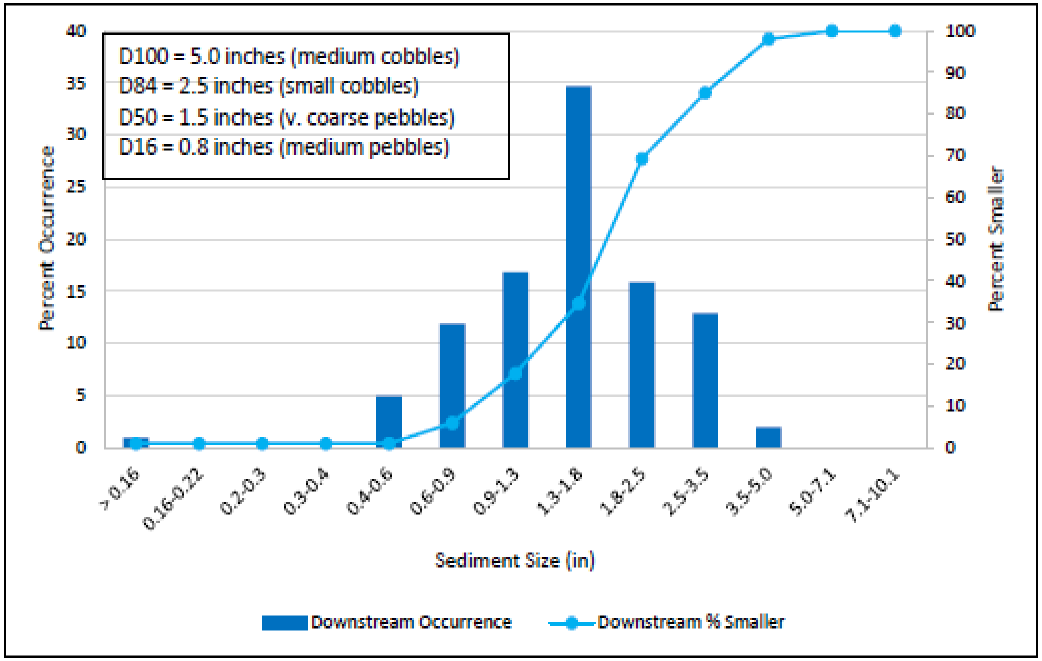
- Visual evaluation of sand
- Gravel fraction measured with pebble count
- No structure in arrangement of surface gravel
- Subsurface characterization
  - No evidence of armored bed surface layer



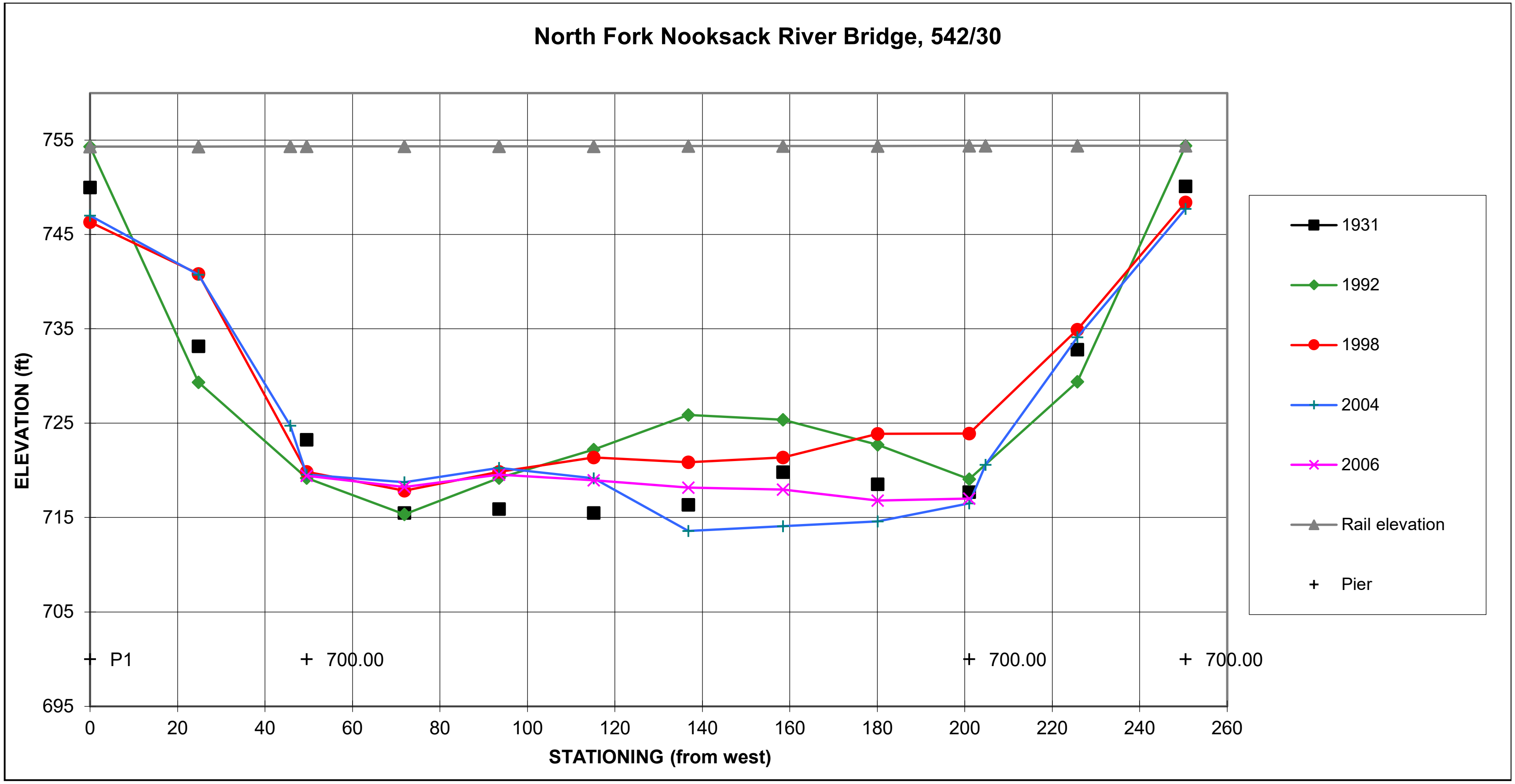
Bed Characterization (Mox Chehalis)



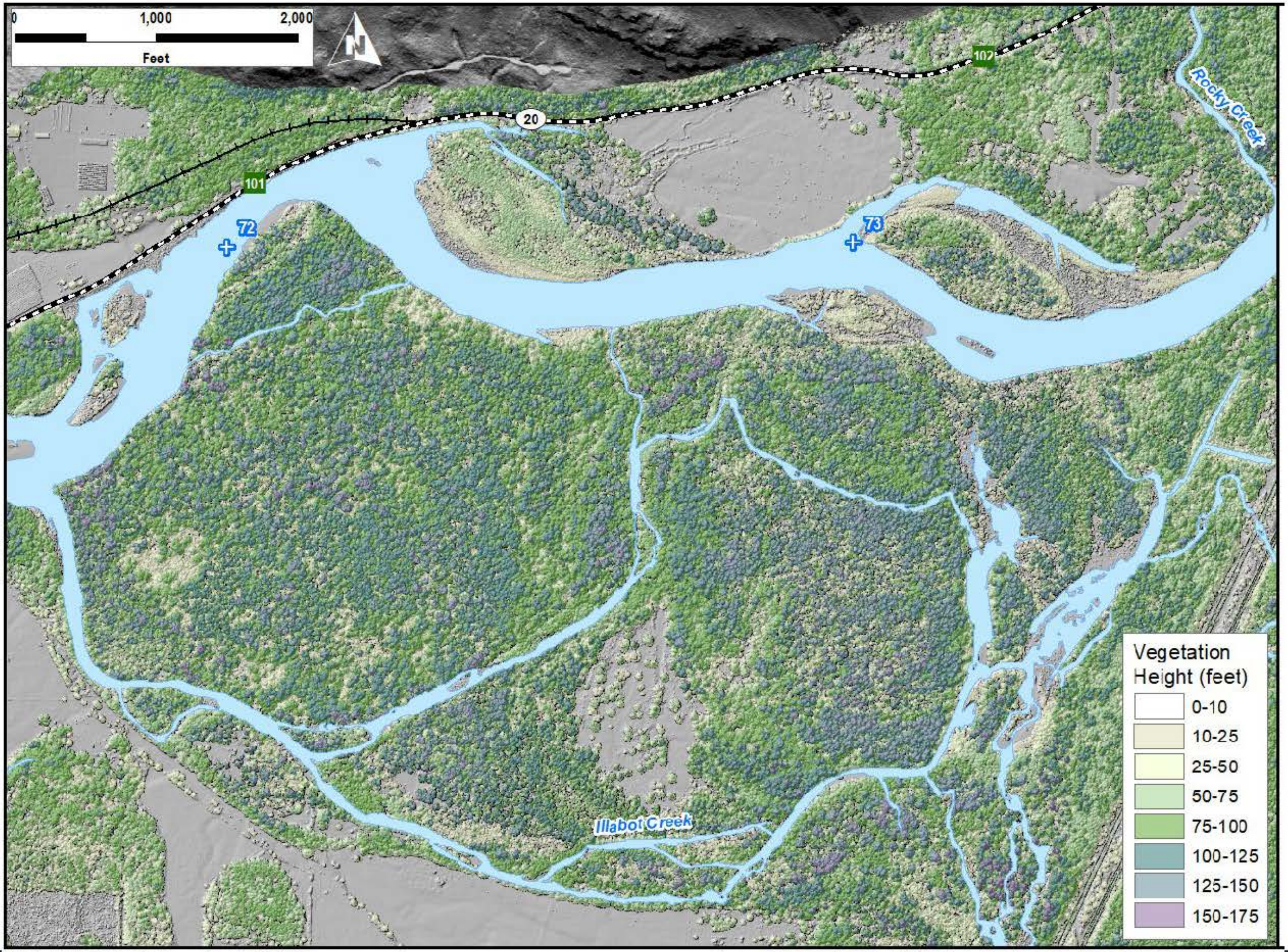
- Visual evaluation of sand
- Gravel fraction measured with pebble count
- Subsurface characterization
  - Bed surface strongly armored (high % SS sand)
- No additional surface structure in surface gravel



Historic Cross Sections

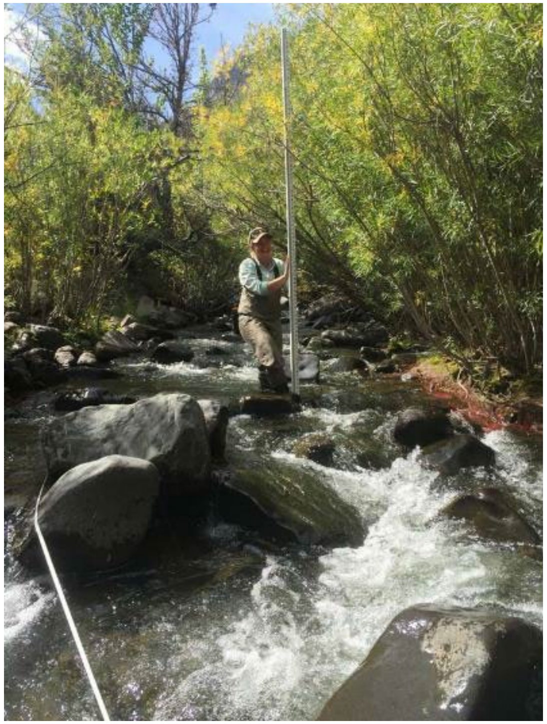


Riparian Conditions



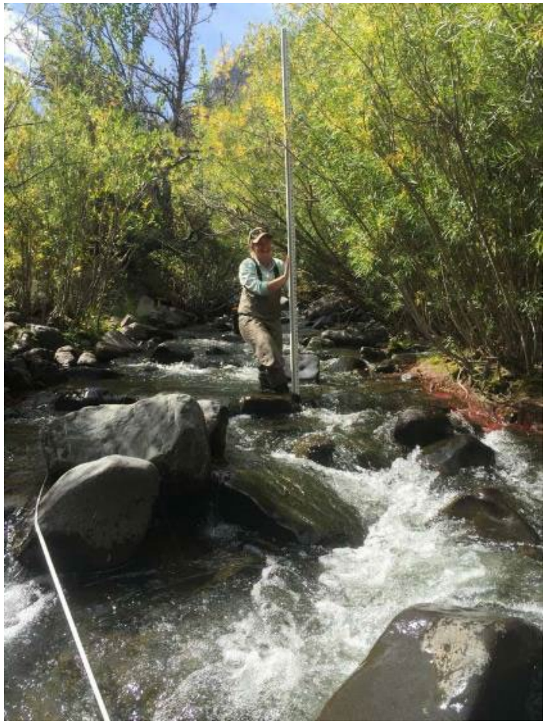
Reference Reaches

- Important for stream restoration, including fish passage projects
- Helps define appropriate streambed material and channel geometry (slope, width, depth)
- Helps us understand bedforms and contribution of wood



Definitions

- ***Project reach*:** the segment of stream in which the project is located
- ***Reference reach*:** A stable segment of stream with consistent slope, geometry, planform, and sediment load that represents, to the best available knowledge, background condition of the project reach
- ***Stable stream:*** A stream, over time (in the present climate), that transports the flows and sediment produced by its watershed in such a manner that the dimensions, pattern and profile are maintained without either aggrading, nor degrading (Rosgen, 1996)
- ***Design reference reach:*** a reach of stream, that matches the desired geometry of a project reach, dictated by constraints.

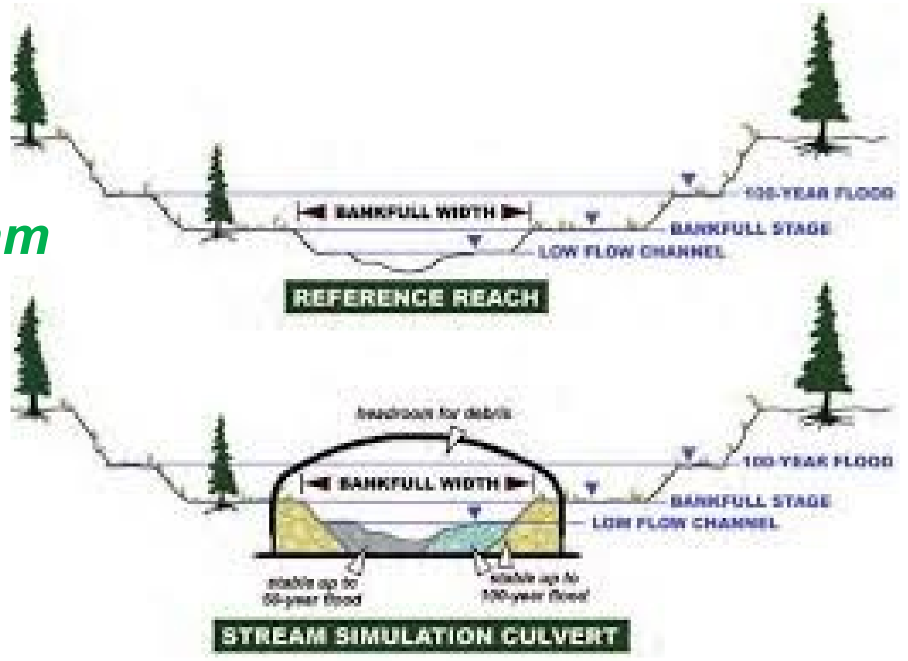


Recommended sequence for identifying a reference reach

Step 1: Identify reference reach by

1. adjacent reaches **OR**
2. same watershed farther *upstream* or *downstream* **OR**
3. adjacent watershed with similar conditions **THEN**

Step 2: Collect relevant information



Option 1: Examine reaches immediately upstream and downstream

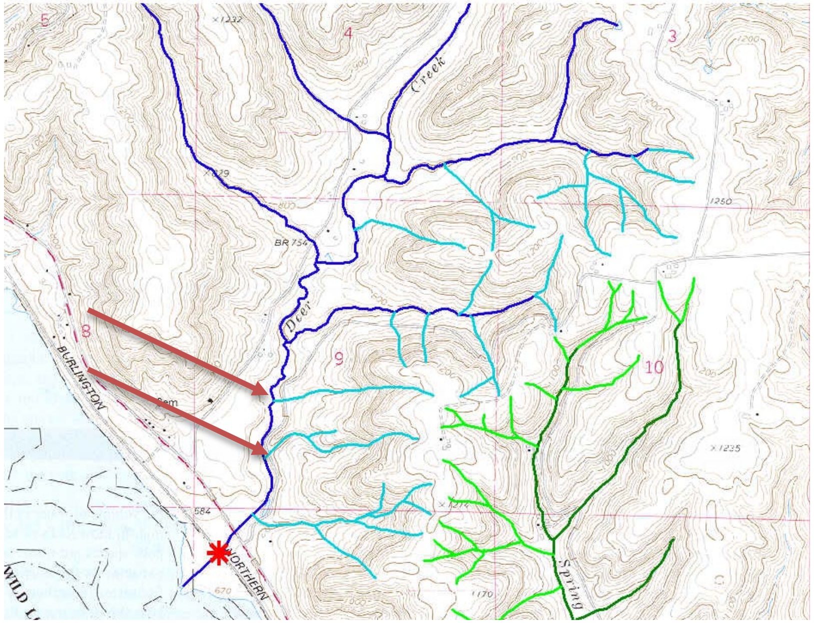
- Does the average stream gradient change *significantly* between upstream and downstream?
- Are there signs of chronic erosion or deposition?
- Are there any man-made features within the active channel? Within the floodplain?
- Are there any sudden changes in sediment size distribution?
- If the answer is "NO" to **all** of the above, then it is appropriate to use as a reference reach.
- If the answer to any question is "YES", go to Option 2

Option 2. Choose a reference reach based on similar reach characteristics.

- Examine a topographic map at the 1:24,000 scale (or finer) for reaches farther upstream and downstream of the project reach.
- When a reach with similar slope and channel confinement is identified, determine the size of the contributing watershed area. Is it similar (+/-20%) to the contributing area above the project reach?
- If "YES", collect reference reach data. If "NO", go to Option 3.

Option 3. Choose a reference reach in an adjacent watershed.

- Examine a topographic map at the 1:24,000 scale (or finer) for reaches in adjacent or very nearby watersheds.
  - Look for reaches with a contributing area similar to that of the project reach (+/-20%).
  - Is the geology, geomorphology, level of development similar?
- If “YES”, collect reference reach data.
- If no appropriate reference reach found, then use ether a design reference reach



Step 2. Gather data on reference reach

a) In what stage of channel evolution is the reference reach?

b) Measure water surface slope during non-flood event

c) Measure bankfull width in at least 3 representative locations;

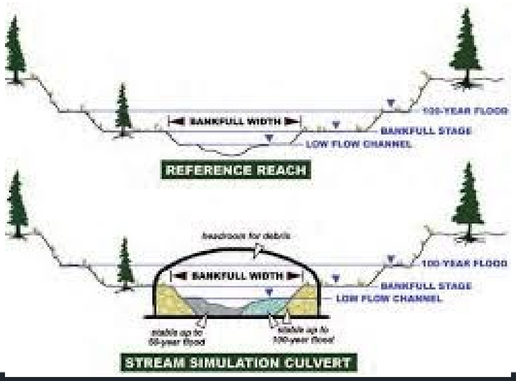
d) Conduct pebble counts in at least 3 locations on rifles or pool tailouts.

e) If there is more than 10% sand and finer, use bulk sampling and analysis for sediment size distribution.

f) Note riparian zone vegetation, canopy density

g) Note presence (or absence) of LWM, especially key pieces.

h) Record geographic coordinates of reference reach, using GPS unit or similar.



Design reference reaches

When unable to obtain a reasonable, natural reference reach due to:

- No unmodified/undisturbed reaches in the area for a reference reach
- Can find a reference reach, but can't implement due to constraints

The design reference reach is a stream reach with the desired gradient of the crossing

- Determined in part due to constraints
- Sediment may be larger than reference reach

Summary

- Site and reach assessments provide the needed context for designing the new stream crossing
- SRAs are comprehensive examinations of local and watershed factors influencing stream behavior at the crossing.
- The assessment includes an evaluation of land use, geology hydrology, geomorphology, and habitat
- Within the reach assessment, a reference reach is selected.
- The process for selecting a reference reach starts with adjacent stream reaches, with the goal of finding a pre-development analogy.
- The search can go to adjacent watersheds if the conditions are reasonably similar.
- It may not always be to find a reference reach; a design reference reach may be needed.

Questions?