

Large Woody Debris and Engineered Logjams

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Some basic guidelines for building a sound foundation for sustained rehabilitation of fluvial ecosystems:

1. Know how physical elements and processes have changed and their significance to the system.
2. Re-introduce or emulate the key elements which have been lost.
3. Understand the consequences of “restoring” natural systems, particularly w.r.t. human development.
4. Adapt land management and infrastructure to accommodate recovery of disturbance regimes that sustain ecological communities.

Cispus River 2004



Hoh River ELJ 8 2005



“Engineered” Logjams Means They are Carefully Analyzed and Designed for a Factor of Safety and a Specified Design Life

- Size, position, and spacing of ELJs based on:
 - Hydraulic analysis of flow behavior near structure(s)
 - Channel response over time
- ELJ architecture & materials based on:
 - Scour analysis
 - Structural stability analysis
 - Material design life analysis
- All structures designed to emulate nature and provide maximum possible benefits to restoring native habitat

Engineered Logjam Design Process

1 Reach Analysis

- Fluvial geomorphology
- Hydrology & hydraulics
- Ecology/Habitat/ESA
- Wood & sediment budgets

3 Risk Assessment

- Risk to habitat and humans
- Factor of Safety
- Engineering Analysis
- System Response

5 Construction

- Materials (trees)
- Access and sequencing
- Flow diversion and de-watering
- Erosion and water quality

2 Feasibility

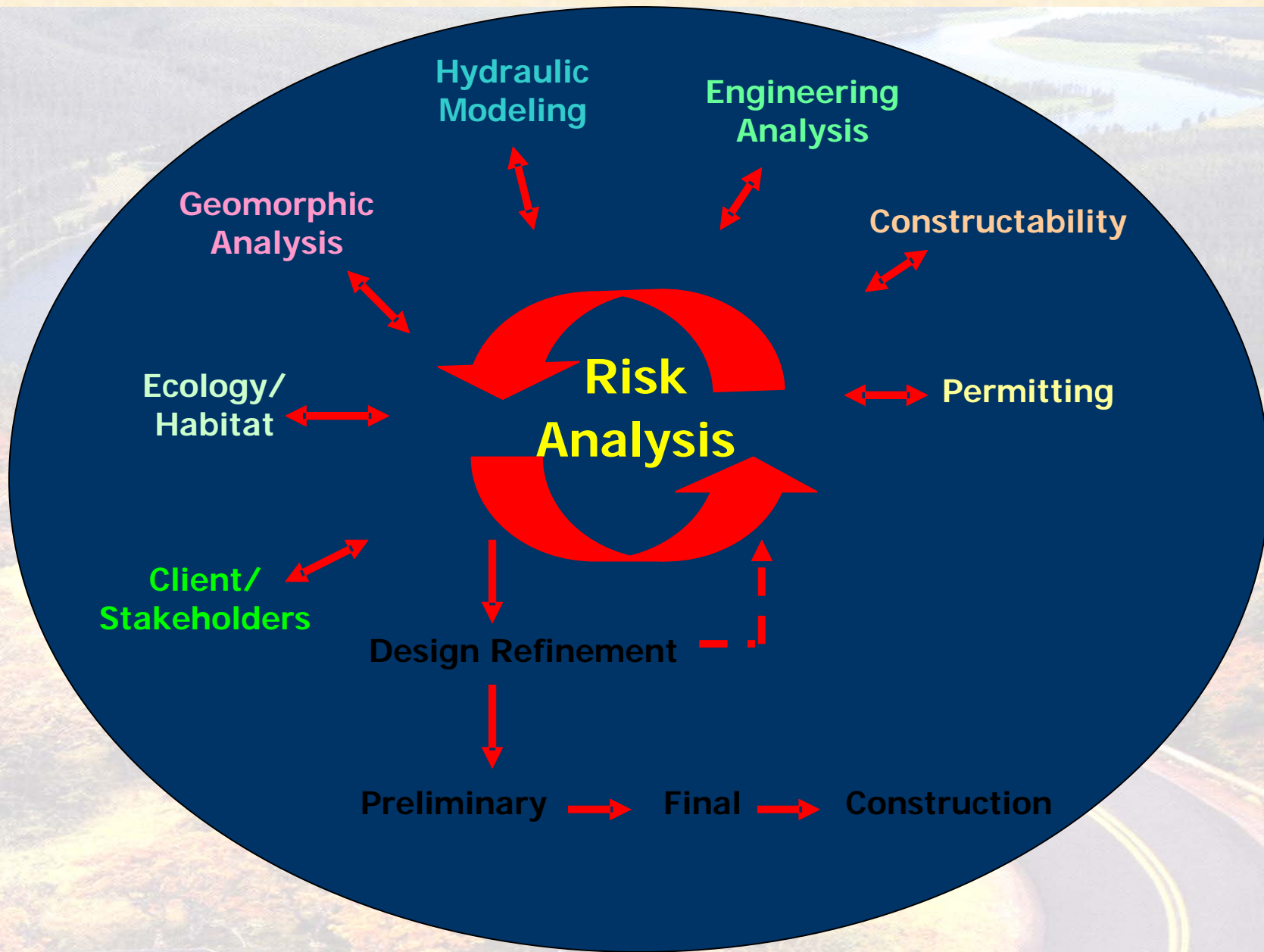
- Opportunities/Constraints
- Stakeholder concerns
- Design Alternatives
- Acceptable Risk and Cost
- Cost Benefit

4 Design

- Type of structure and architecture
- Number of structures, size, location
- Force balance
- Scour and deposition
- Channel dynamics

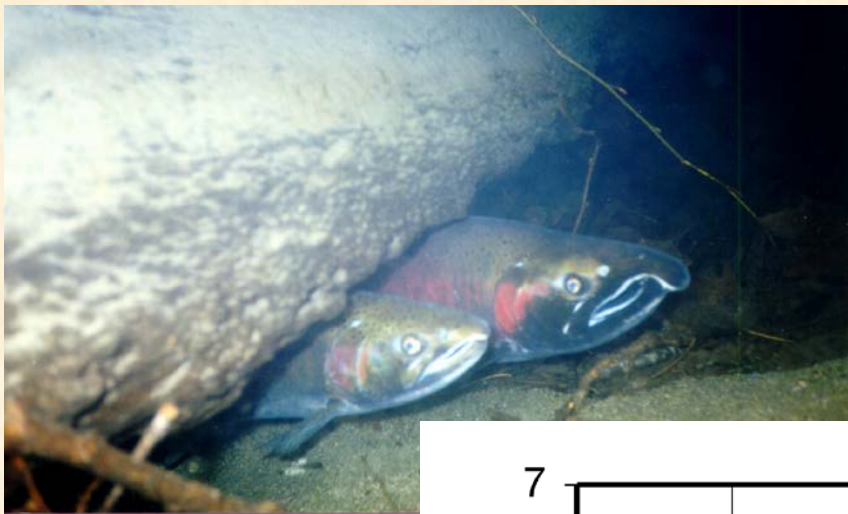
6 Inspection Monitoring

- Culling or repair
- Re-vegetation
- Accumulation/Loss of ballast
- Flotsam accumulation

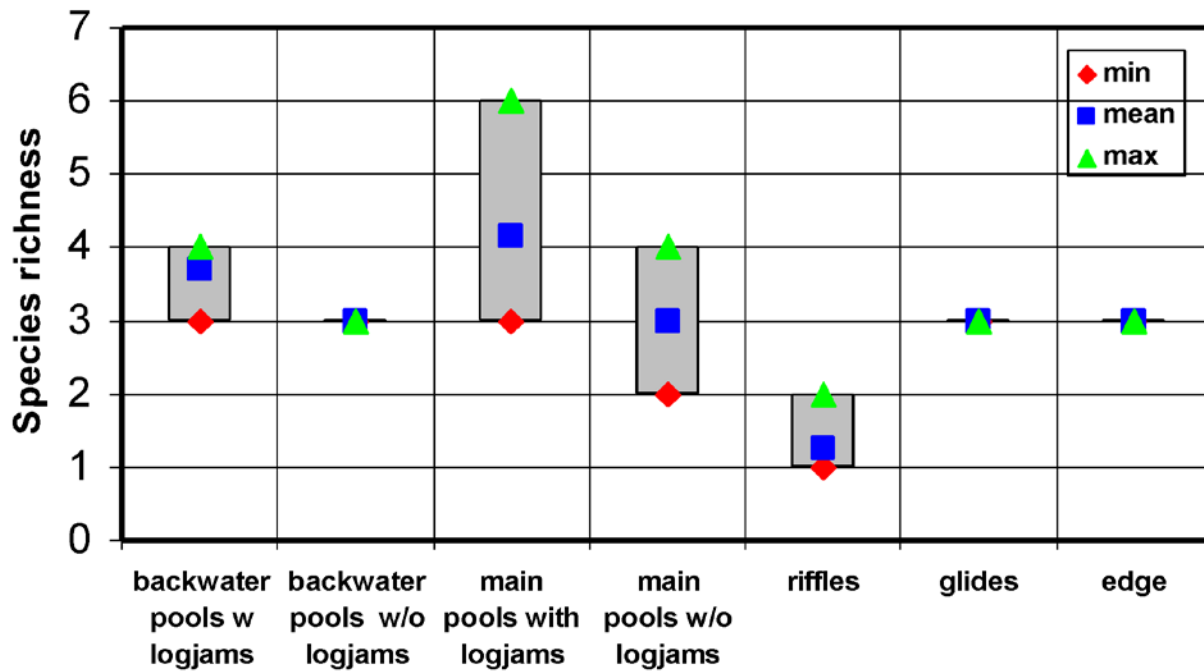


Fish Benefits

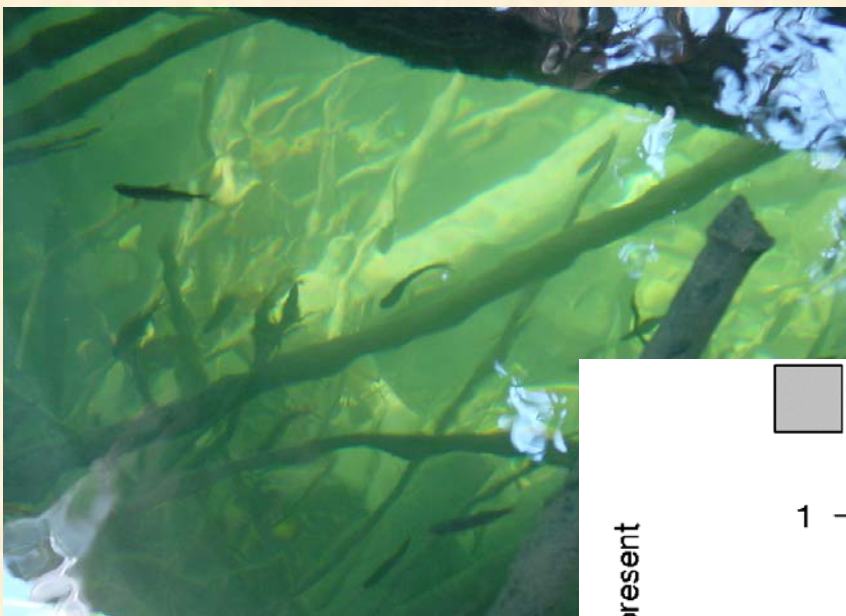




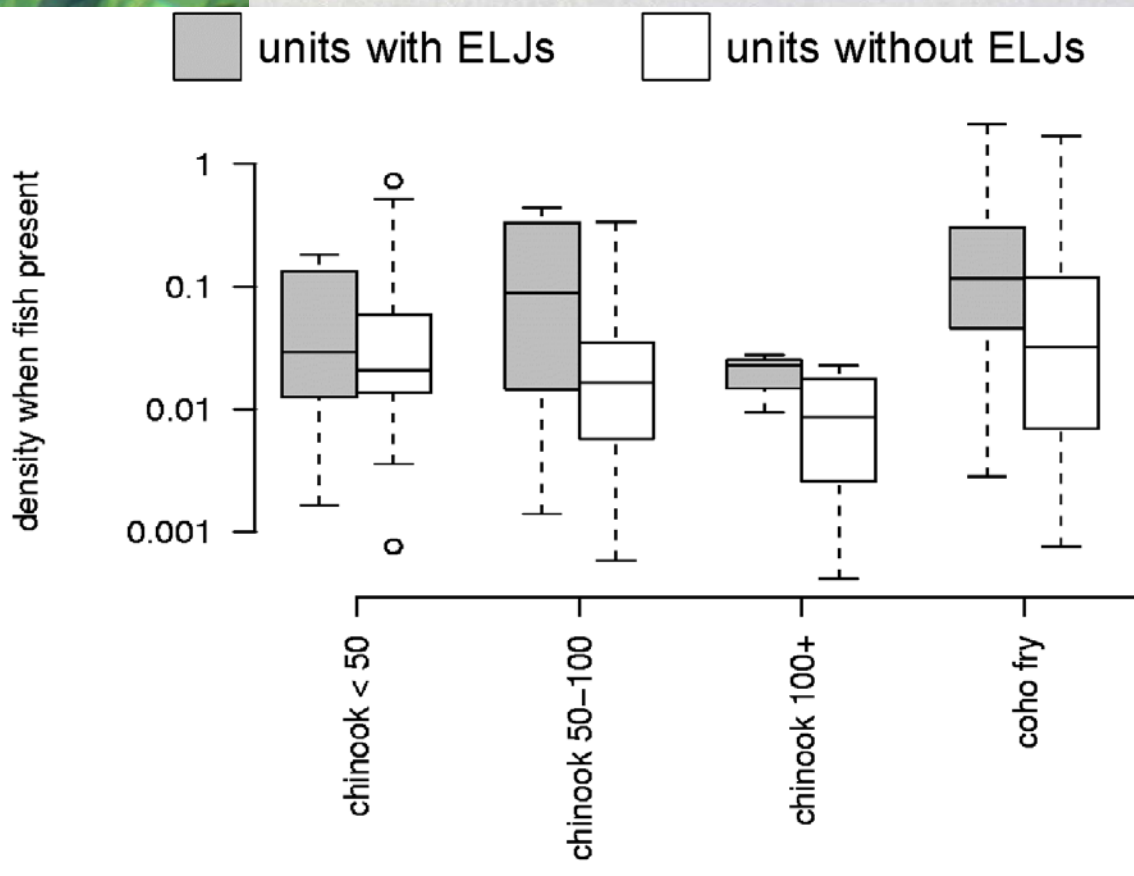
Species richness
increases in rivers with
the addition of logjams



Pess et al. 2002



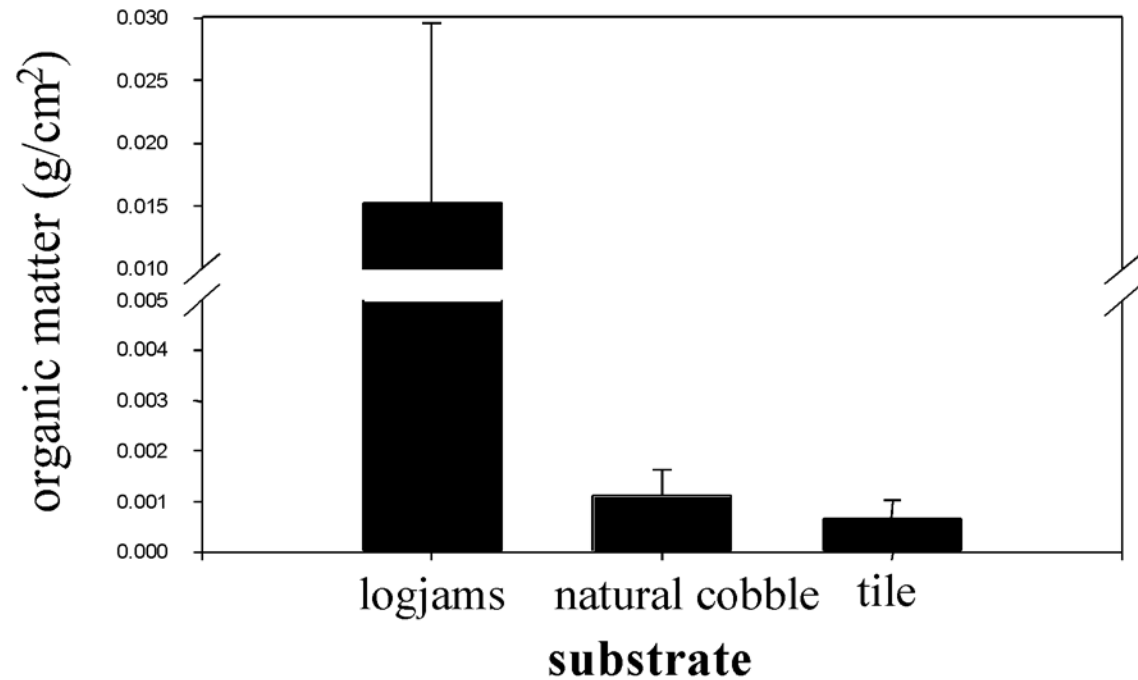
Fish density increases at logjams



Pess et al. 2002



Organic matter is higher at logjams



Pess et al. 2002



Logjams also make great
habitat for *Homo Sapiens*

The Many Types of ELJ Projects:

- **Bank roughening**
- **Bank stabilization**
- **Flow deflection**
- **Flow bifurcation**
- **Grade control**



Smooth shoreline:

High velocity flowline hugs shoreline where there is lack of boundary roughness provided by woody vegetation and channel shoreline is subjected to shear stresses.



Rough shoreline:

High velocity flowline is offset by boundary roughness provided by woody vegetation, reducing shear stress along the channel shoreline.

Natural Bank Roughening



Chilkat River, Klukwan, Alaska

An aerial photograph showing a river winding through a landscape of green fields and dense forests. A road with a double yellow line crosses the river, illustrating the concept of flow deflection. The text "Flow Deflection" is overlaid in the center of the image.

Flow Deflection



Engineered logjam constructed in 1999 to protect Forest Road 23, Cispus River. November 2004.

An aerial photograph of a winding river flowing through a lush, green landscape. The river curves through the scene, bordered by dense forests and rolling hills. In the foreground, a paved road with yellow double lines runs parallel to the river. The overall scene is bright and clear, suggesting a healthy aquatic environment.

Evaluating Design Principles – Examples from Actual Projects:



Williams River, NSW, Australia

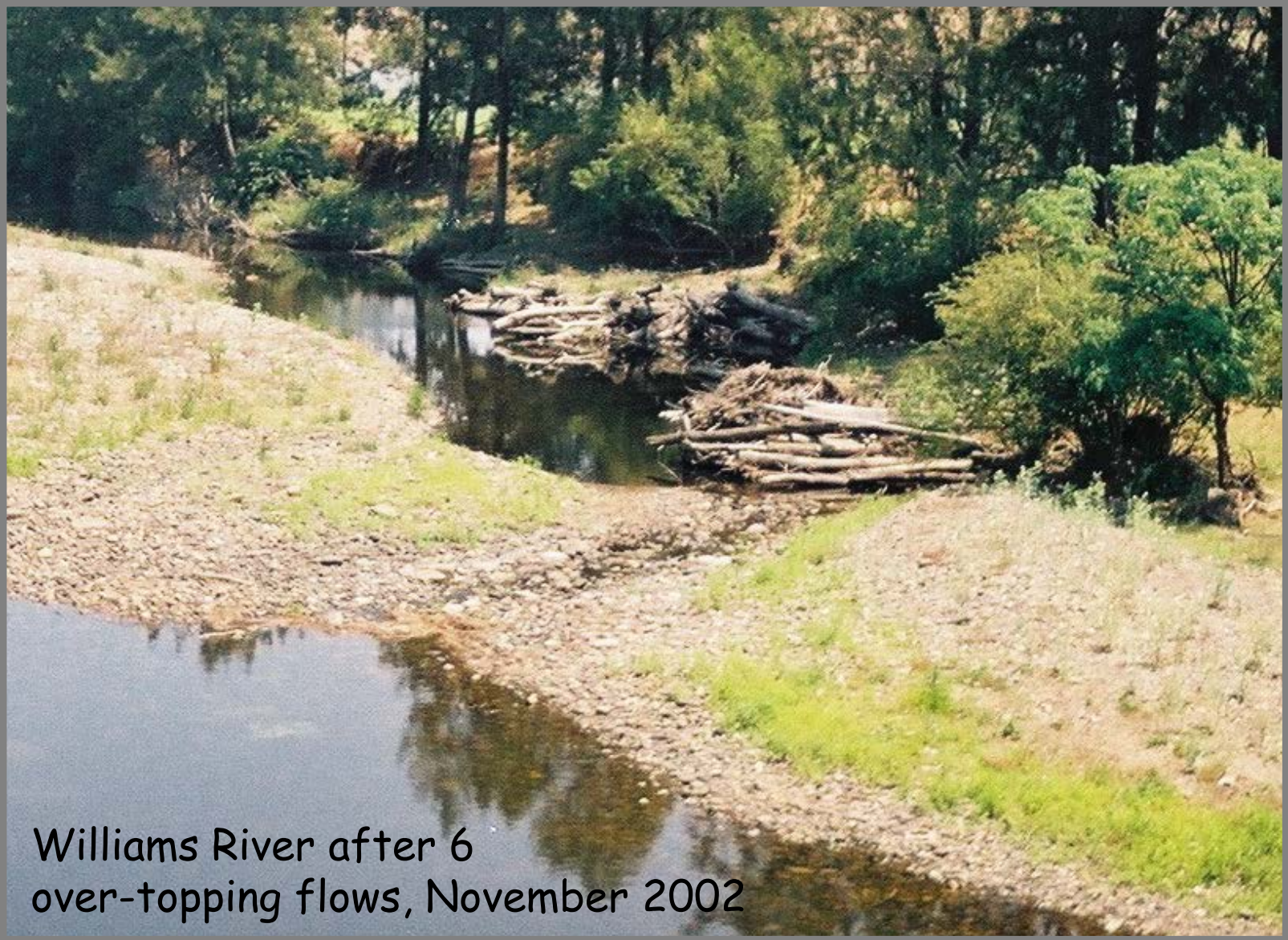


Williams River ELJ
As-Built Conditions, 2000

SEP 24 2000



Williams River during flow
submerging structures by 2 m.

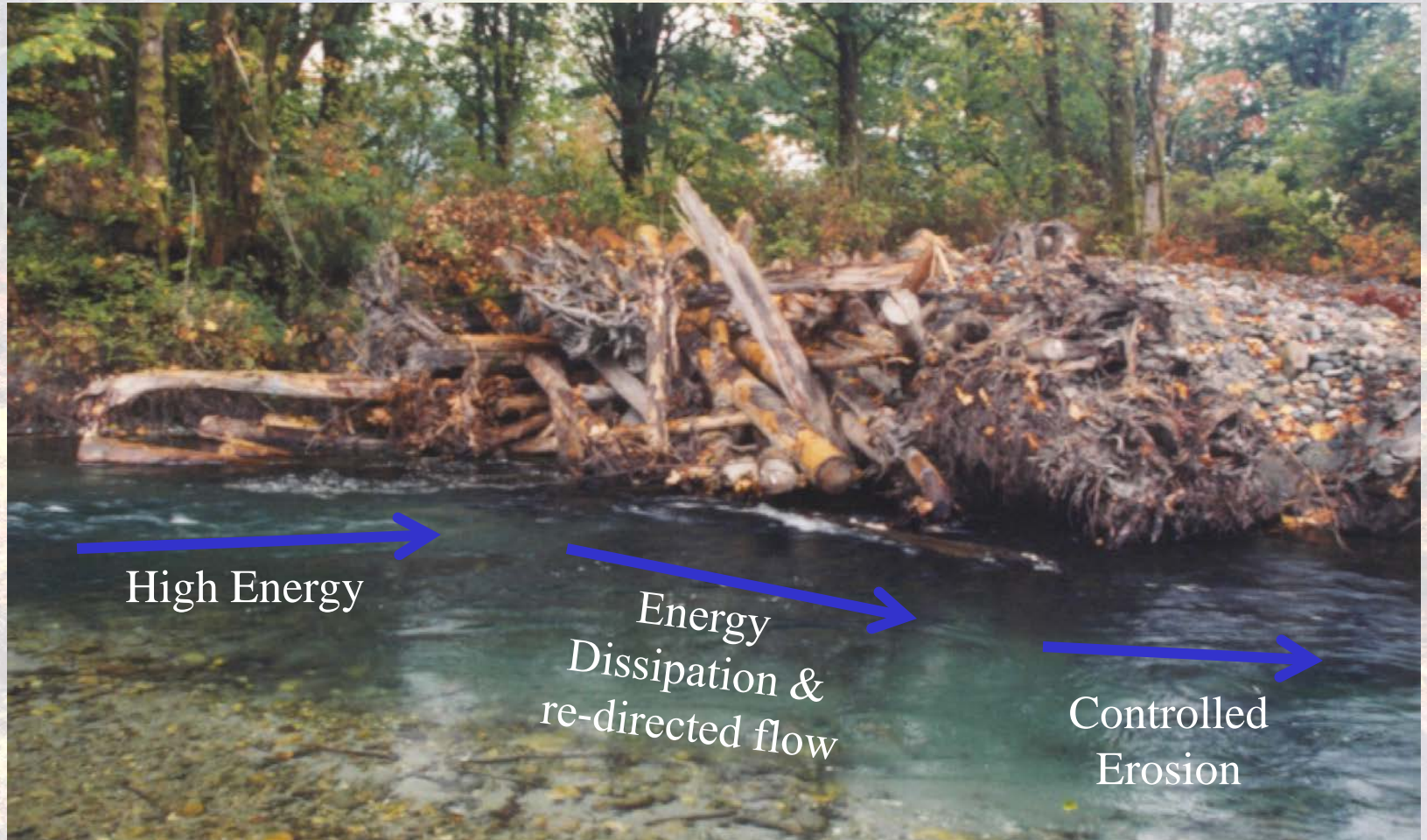


Williams River after 6
over-topping flows, November 2002

An aerial photograph of a winding river, likely the Stillaguamish River, flowing through a lush, green forested landscape. The river curves through the terrain, surrounded by dense trees and some open fields. In the foreground, a paved road with double yellow lines runs parallel to the river. The overall scene is a natural, scenic view of a river valley.

North Fork Stillaguamish Project

ELJ Functions – Hard Point Flow Deflectors



An aerial photograph of a winding river flowing through a landscape of green fields and dense forests. A road with double yellow lines runs parallel to the river in the foreground. The text "ELJ no.1" is overlaid in the center of the image.

ELJ no.1

ELJ no. 1

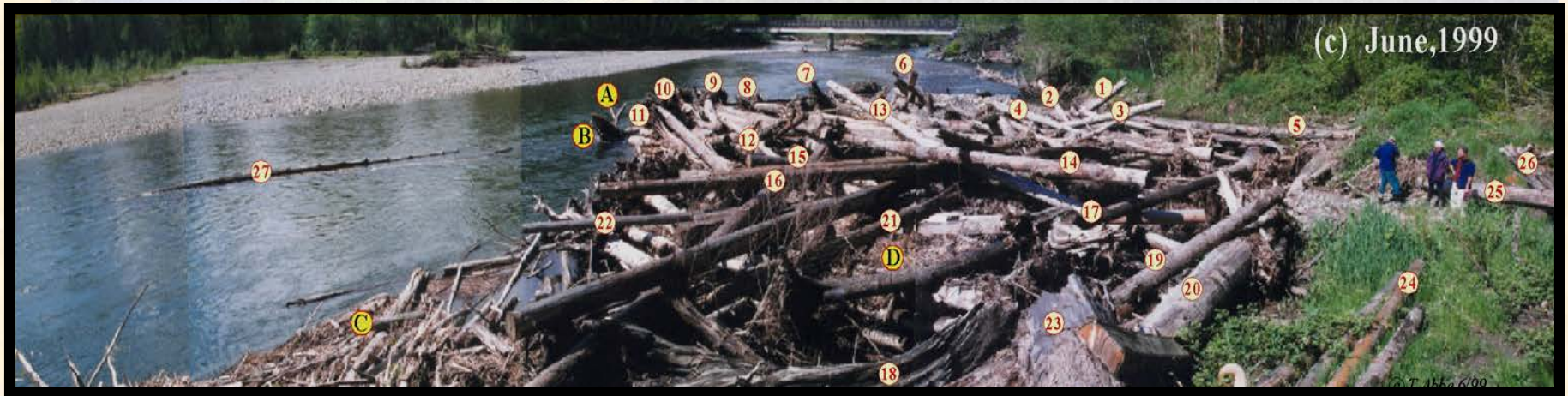
North Fork Stillaguamish River ELJ #1,
1998-1999.

(a) September, 1998



1998

ELJ no. 1



1999

ELJ no.1



2001

ELJ no. 1



2004

ELJ no.1



2005



ELJ no.2

ELJ no.2



→
Mainstem channel

ELJ 2

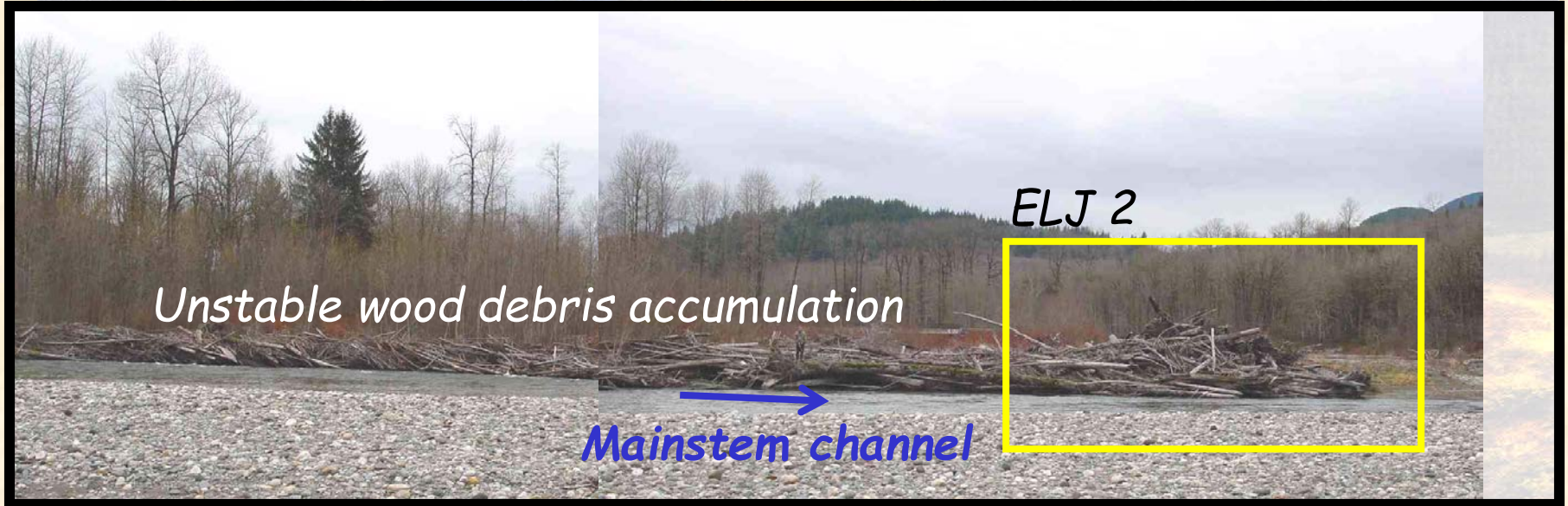
1998

ELJ no.2



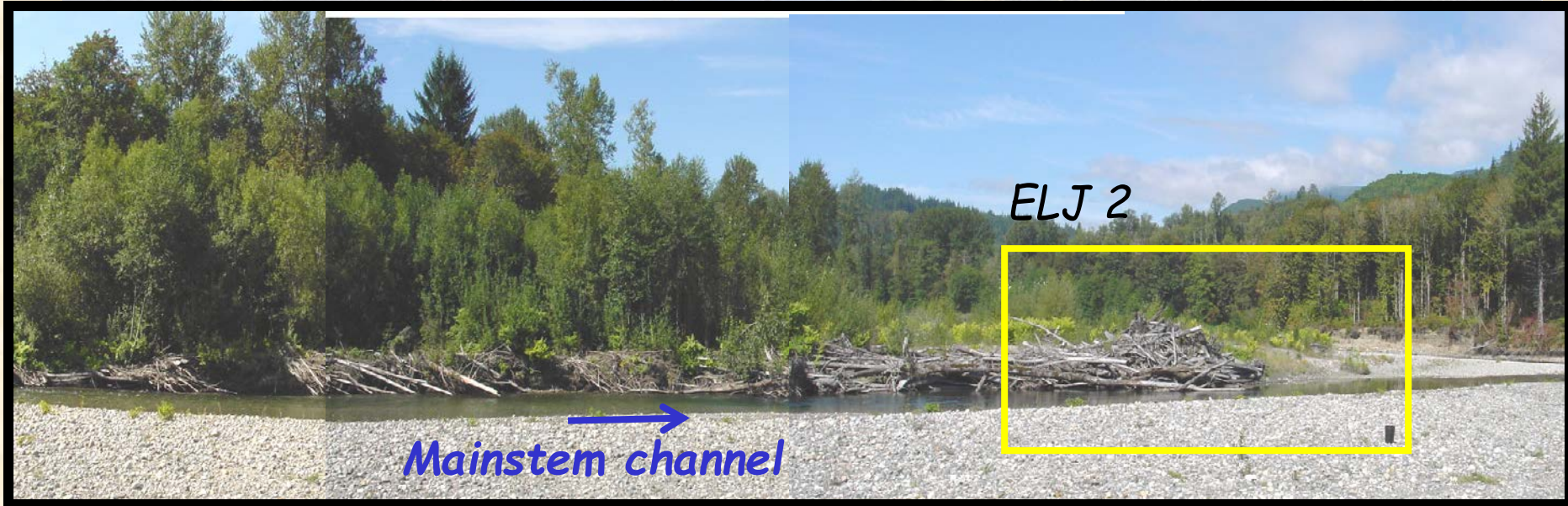
1999

ELJ no.2



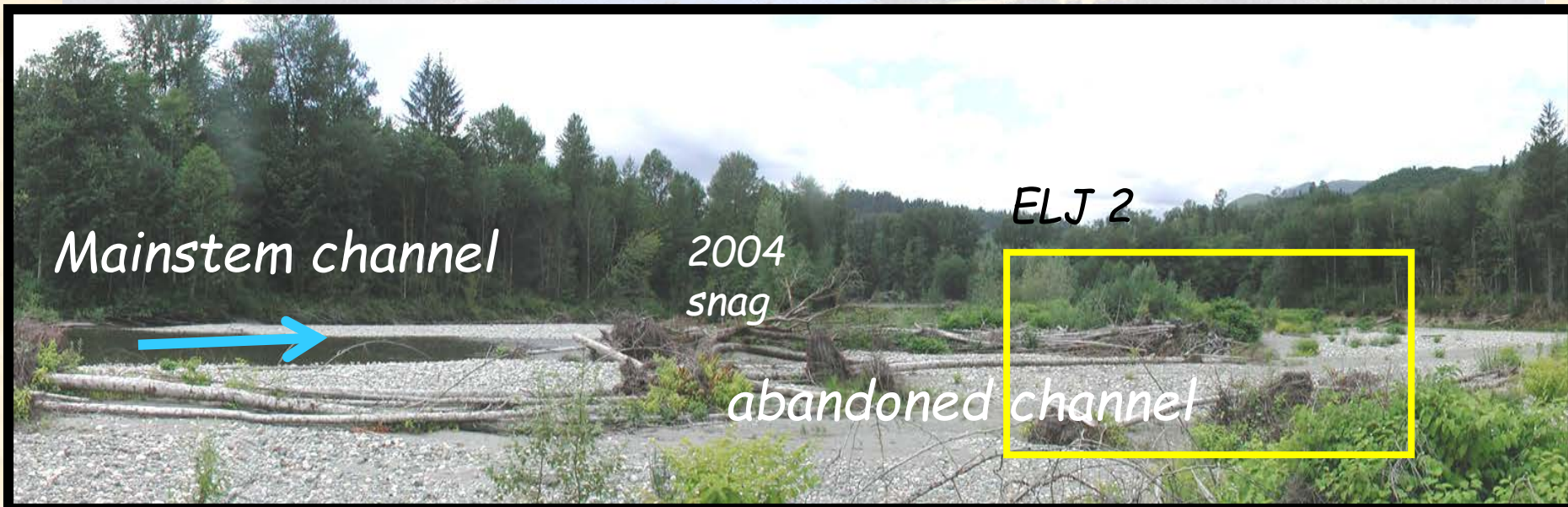
2000

ELJ no.2



2001

ELJ no.2



ELJ no.2



ELJ no. 2



2001

3 years after construction, ELJ 2 with racked woody debris and only tips of key member rootwads visible. Main channel has split into 2 channels around the ELJ.



2005

7 years after construction, a significant decrease in racked woody debris has occurred and key member rootwads are much more visible. Main channel flowing entirely to left of ELJ.



ELJ no.3

ELJ no. 3



1998

ELJ no.3



1999

ELJ no. 3



2000

ELJ no. 3



2001

ELJ no. 3



2002

ELJ no.3



*New racked
debris*

**Note pitch of broken log:
*downstream tip is pointed down***

2004

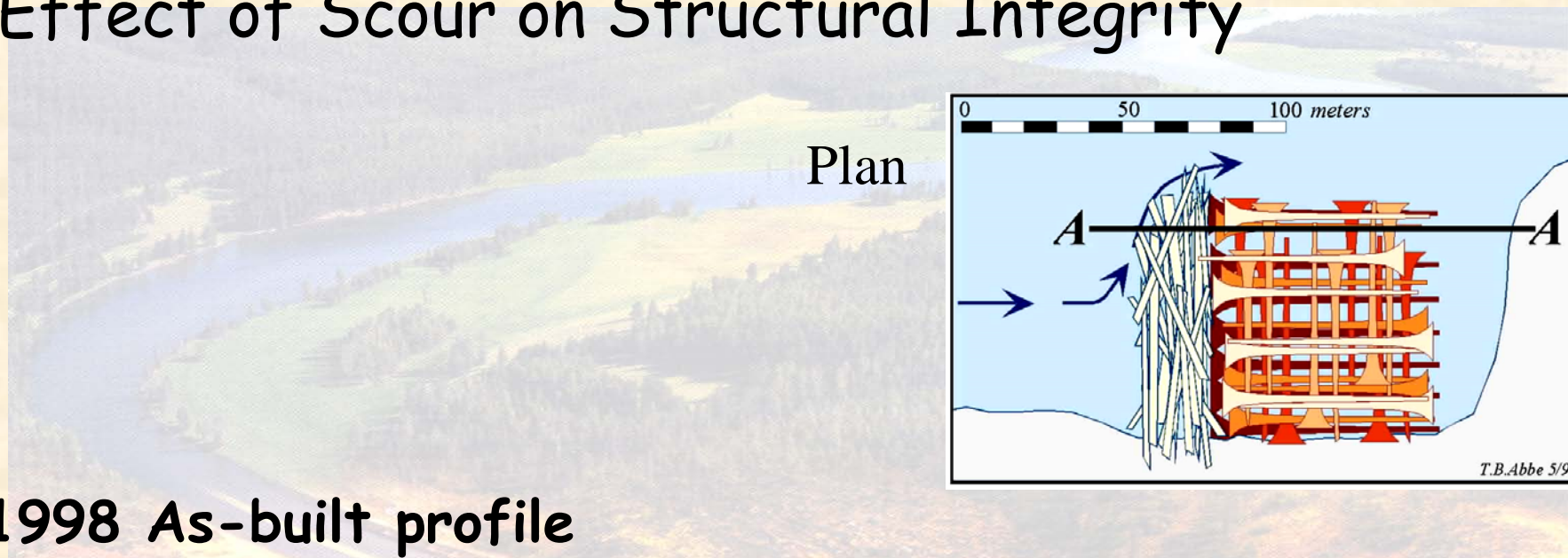
ELJ no.3



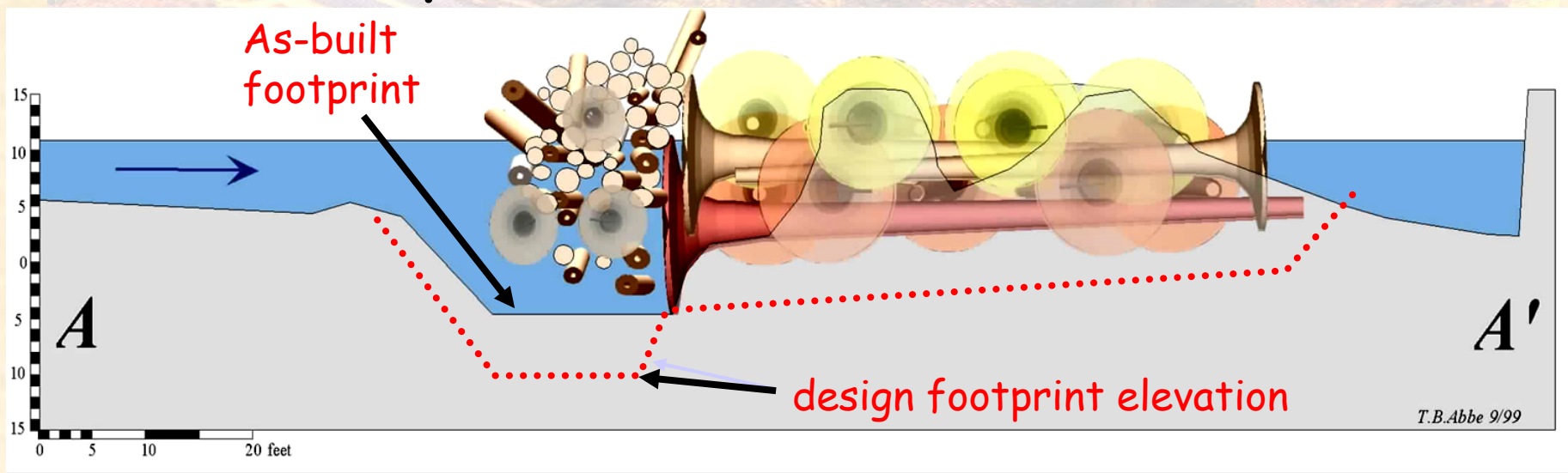
Note that pitch of broken log has reversed, with downstream tip pointed up, indicated upstream corner of structure has settled (~1 m) due to undercutting scour.

2005

Effect of Scour on Structural Integrity



1998 As-built profile

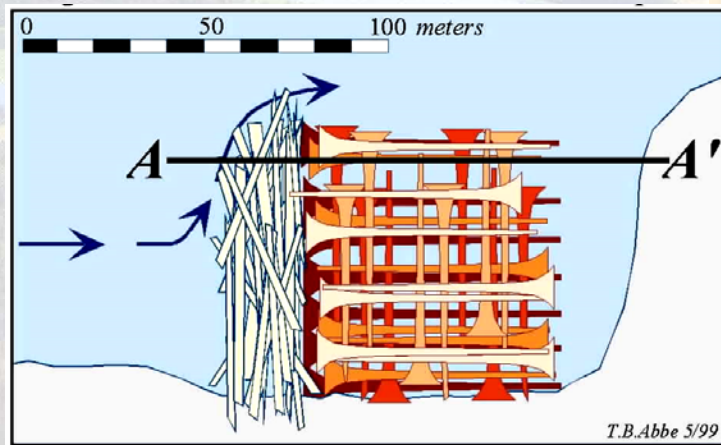


North Fork Stillaguamish ELJ #1, Log #5

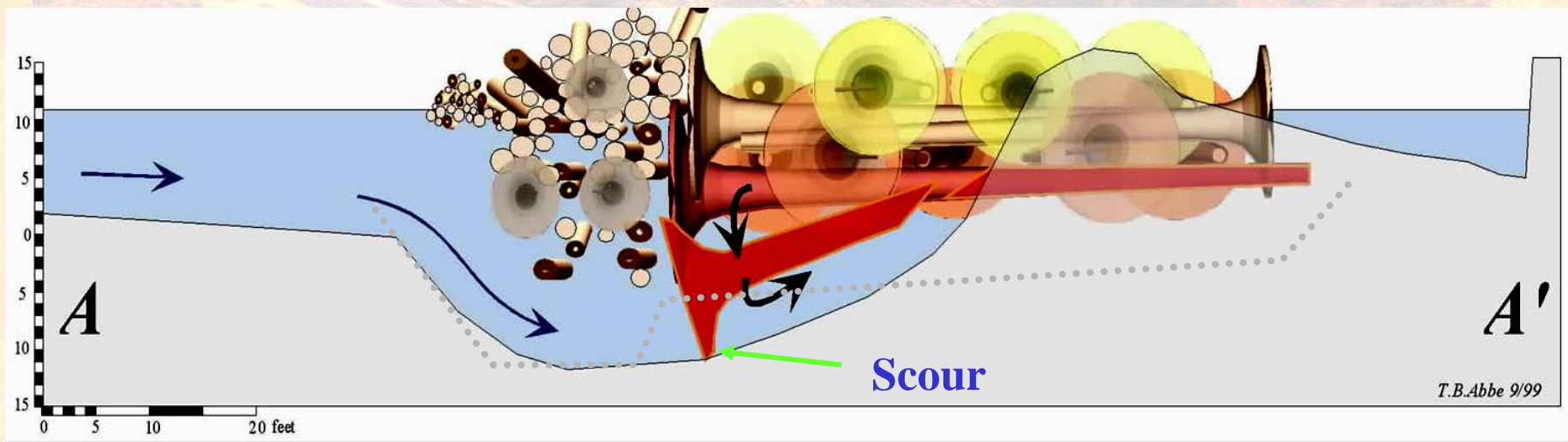
Effect of Scour on Structural Integrity:

Logs sink

Plan



1999 Profile (after 8 overbank flow events)

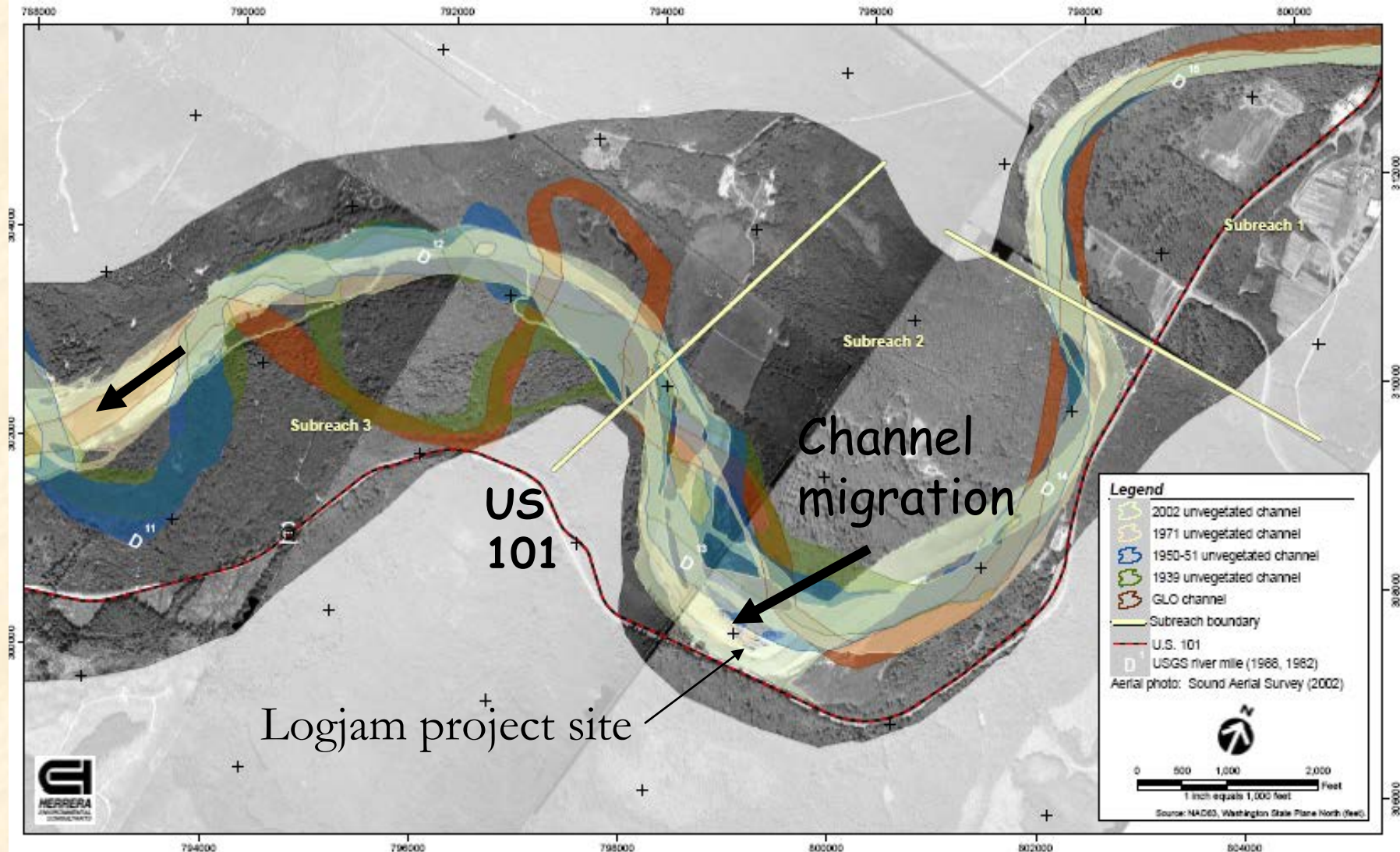


North Fork Stillaguamish ELJ #1, Log #5

The Hoh River Project



The Hoh River moves at rates up to 30 m/yr (100 ft/yr)



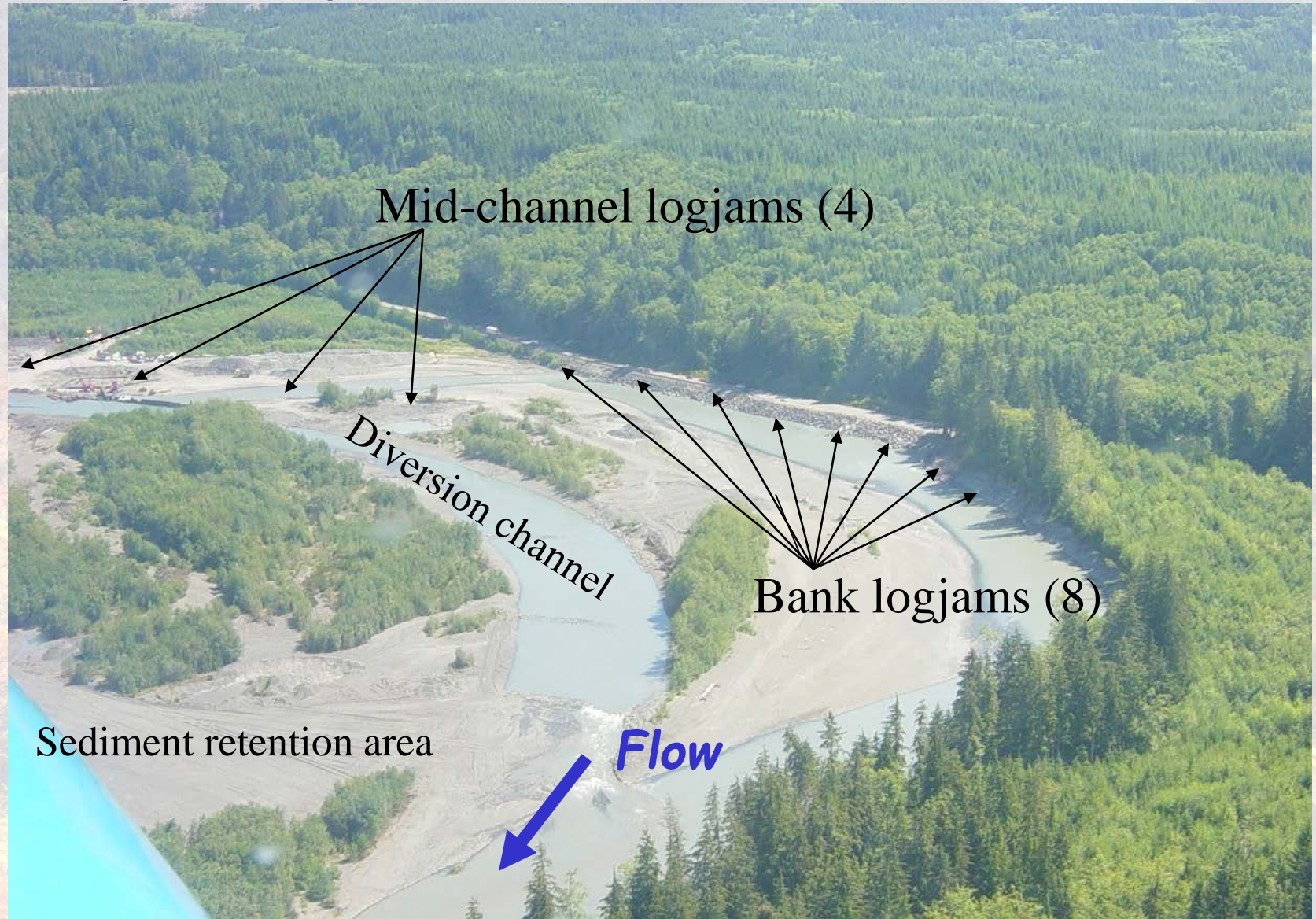
“Natural Analogs”

The Hoh River at Nolan Creek provides a current analog for Hoh Project concept of “chute” meander cut-off:

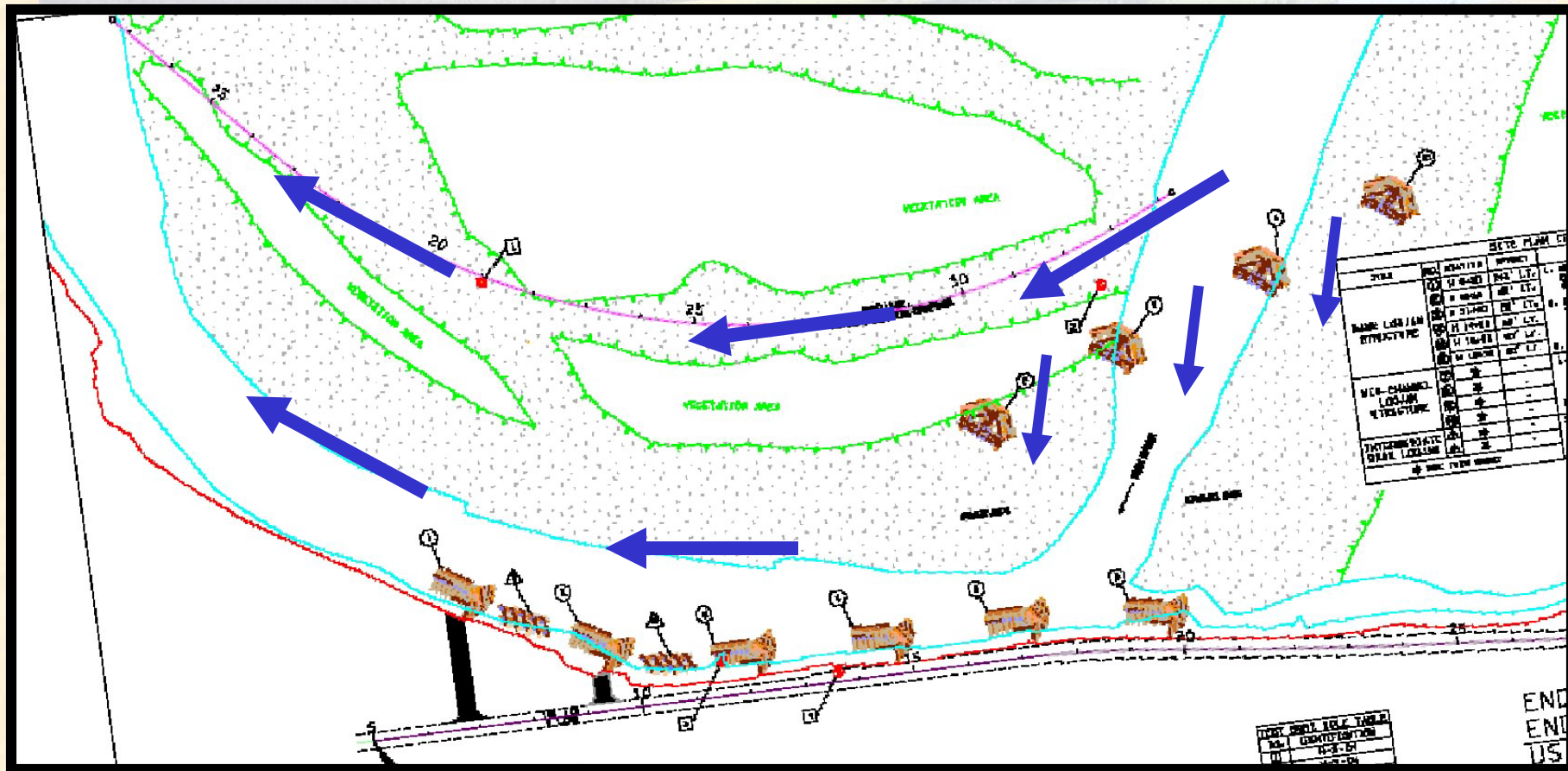


March 29, 2004

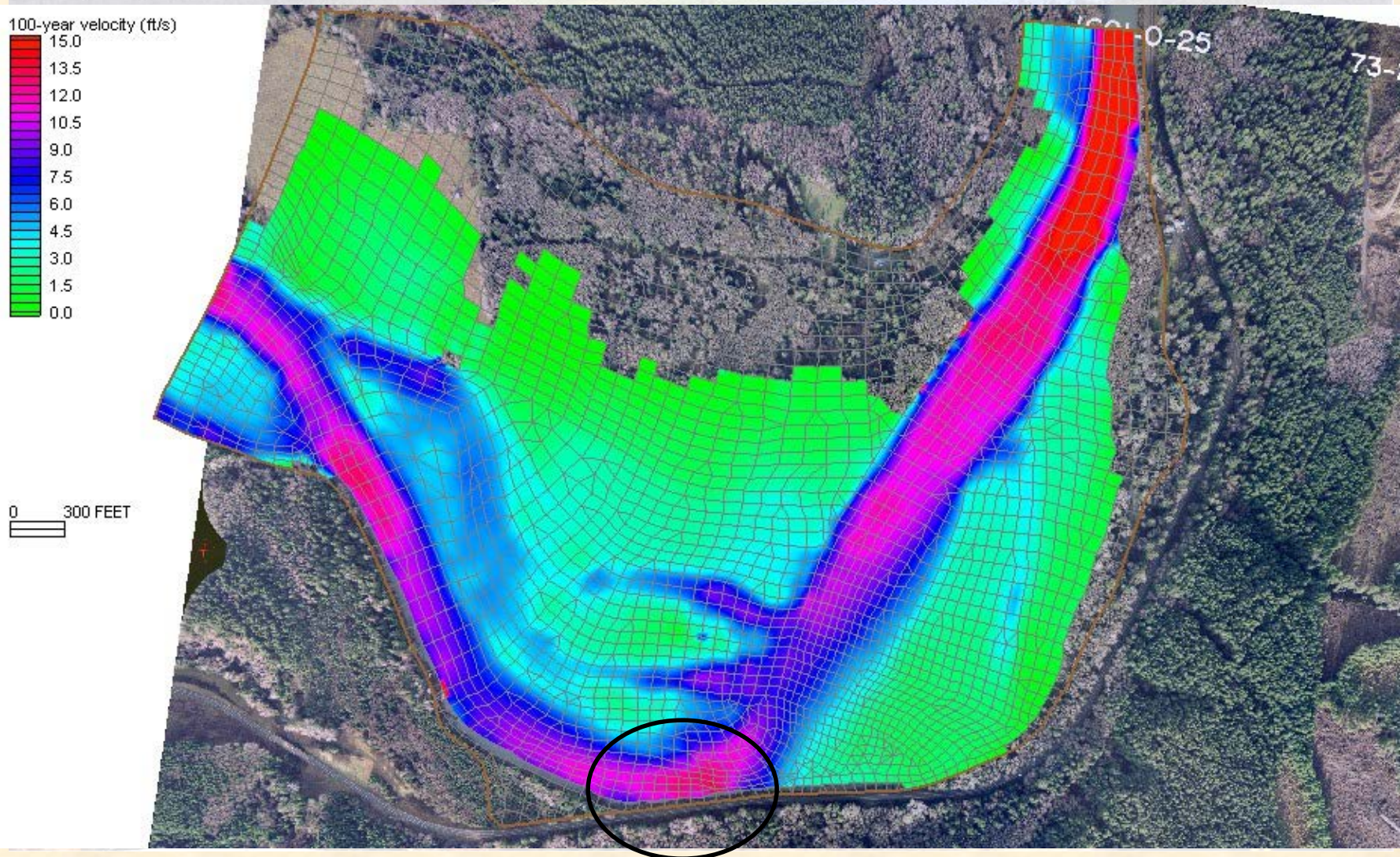
Major Project Elements



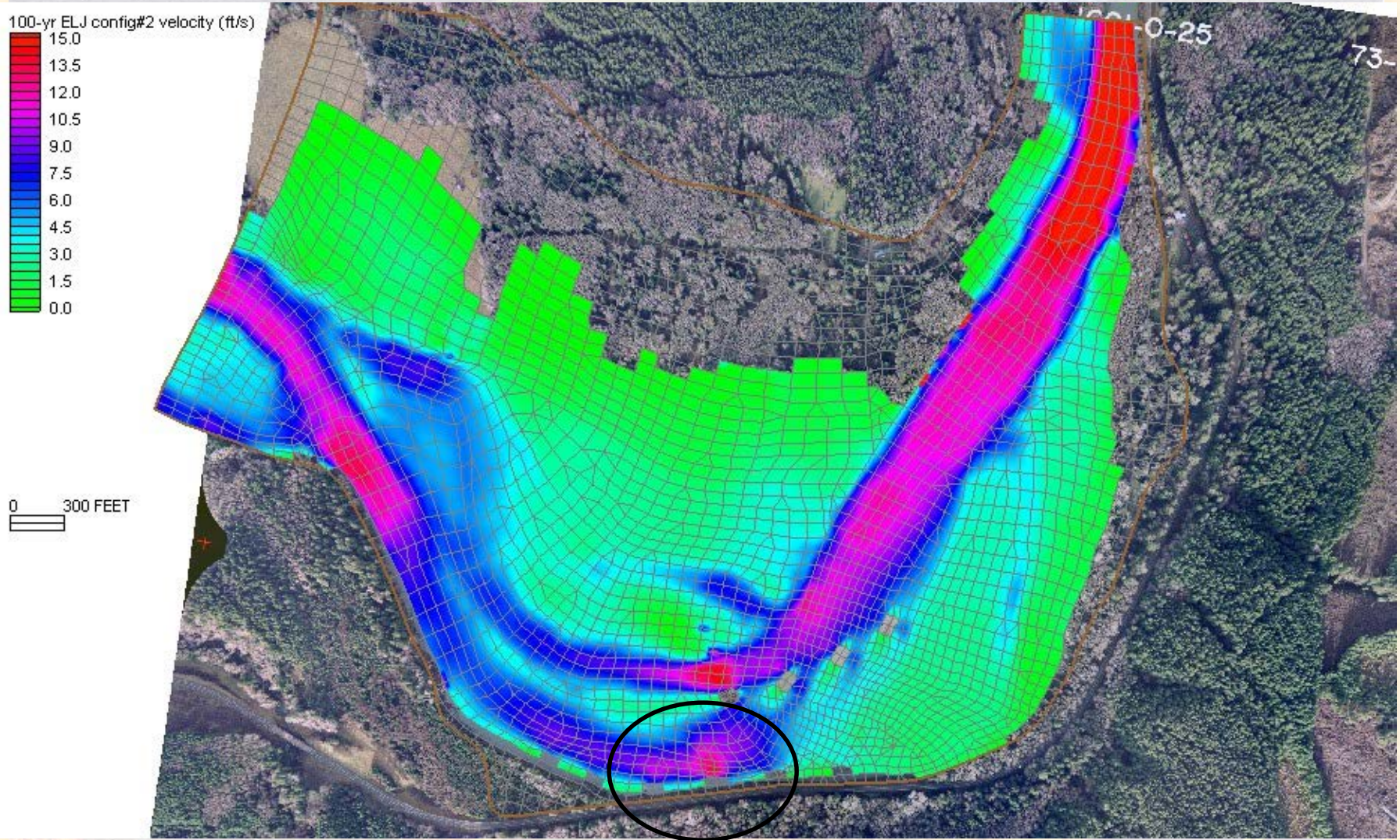
Hoh project objective: get river away from Highway 101



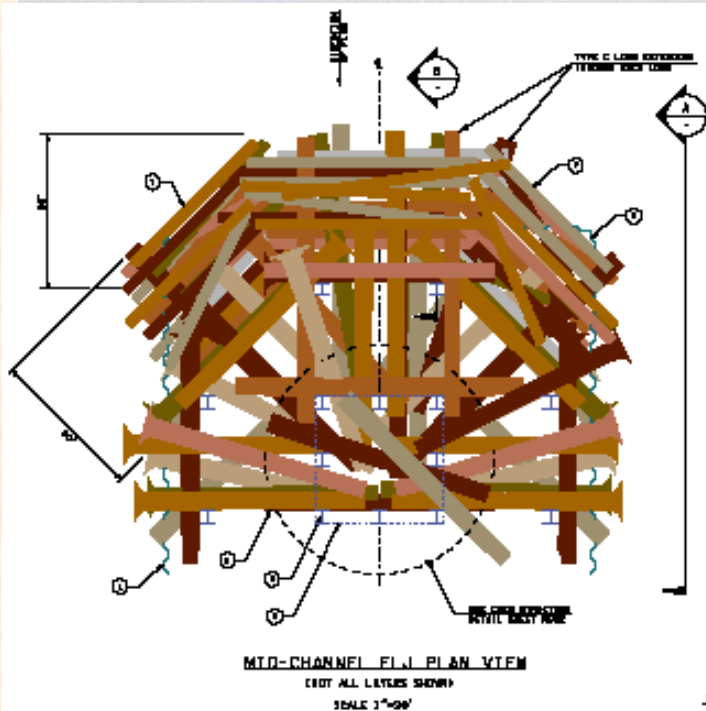
Depth averaged velocity (ft/s) output from FESWMS for existing conditions during 100 yr peak flow event (67,000 cfs)



Depth averaged velocity (ft/s) output from FESWMS for proposed conditions during 100 yr peak flow event (67,000 cfs)

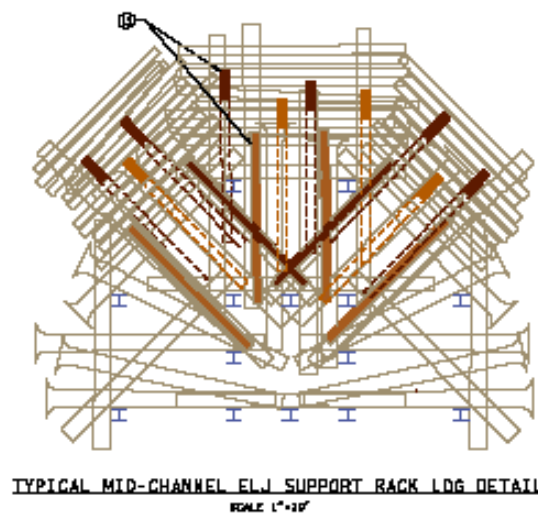
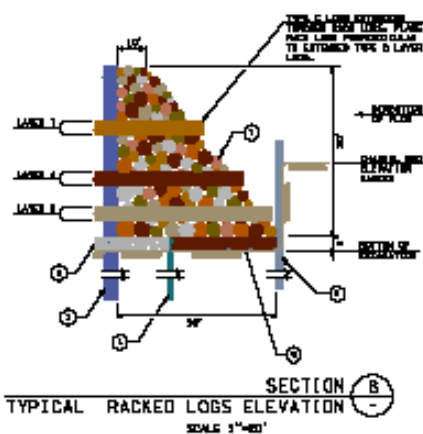
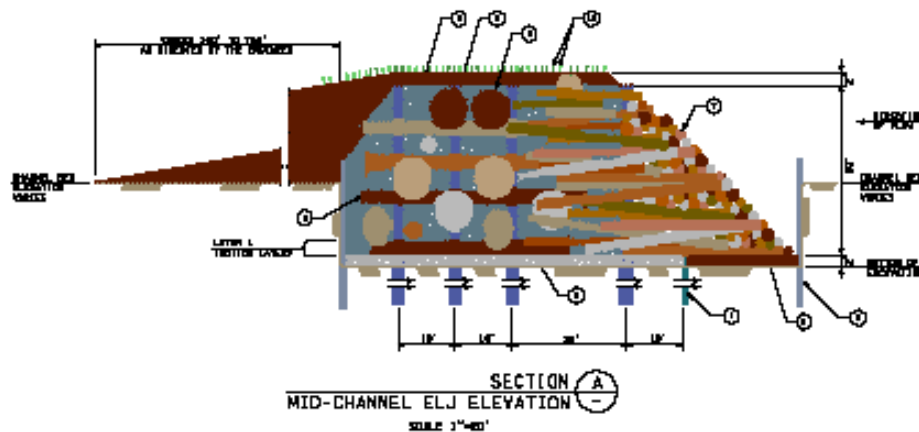


Mid-channel ELJ plan and section view



MID-CHANNEL STRUCTURE CONSTRUCTION NOTES

- ① PERMANENT SHEET PILE (SEE SHEET INDEX FOR PILE LAYOUT)
- ② HP 14 X 3 1/2 I BEAM SHEET PILE FOR PILE LAYOUT
- ③ LAYERED LOGS (SEE SHEET INDEX FOR LOG LAYER LAYOUT)
- ④ 4" X 4" X 24" GROSS STRUCTURE REINFORCEMENT BEAM (SEE SHEET INDEX FOR GROSS STRUCTURE DETAIL)
- ⑤ TEMPORARY SHORING (SEE SHEET INDEX FOR LAYOUT)
- ⑥ LIGHT LOGS: RIPRAP AND NATIVE MATERIAL FROM STRUCTURE EXCAVATION
- ⑦ ROCK LOGS: TIGHTLY PACKED ON 3 UPSTREAM FACES OF STRUCTURES
- ⑧ LIGHT LOGS: RIPRAP
- ⑨ NATIVE MATERIAL FROM STRUCTURE EXCAVATION
- ⑩ PLANTING BY OTHERS
- ⑪ ADDITIONAL SUPPORT ROCK LOGS

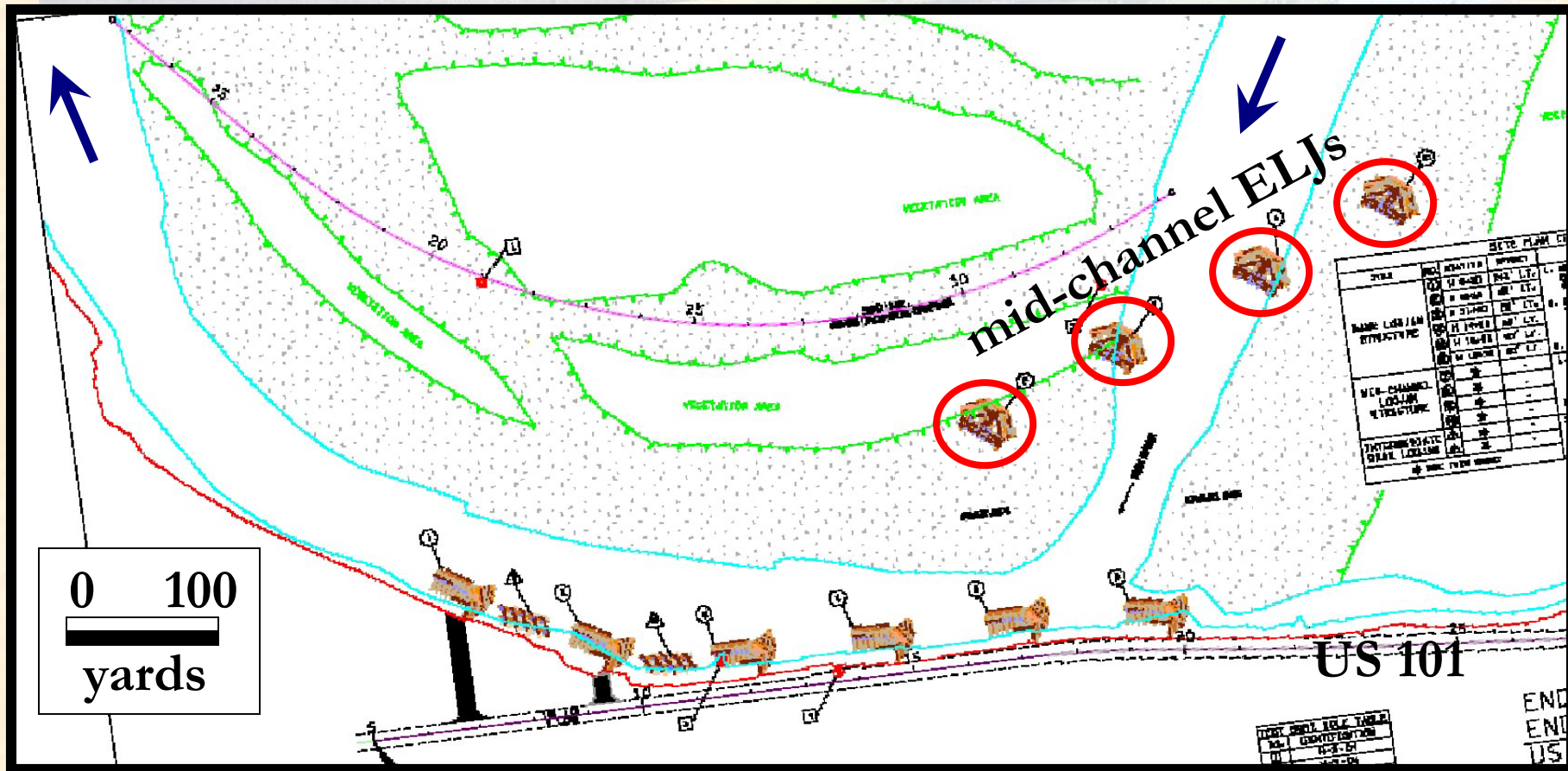


Almost done, October 2004





Hoh River project site in Spring of 2004 prior to construction.



Hoh project site design layout



Herrera concept figure of how we predicted the project site would look in 2005.



Hoh project site as-built conditions in October 2004.



**Hoh project site 12-15-04,
after a 30,000 cfs peak flow (~2 yr recurrence interval).**



**Hoh project site 02-01-05,
after two peak flows of ~30,000 cfs.**

An aerial photograph showing a winding river flowing through a landscape of green fields and dense forests. In the foreground, a two-lane road with yellow double lines curves through a forest with autumn-colored trees. The text "South Fork Tolt" is overlaid in the center of the image.

South Fork Tolt









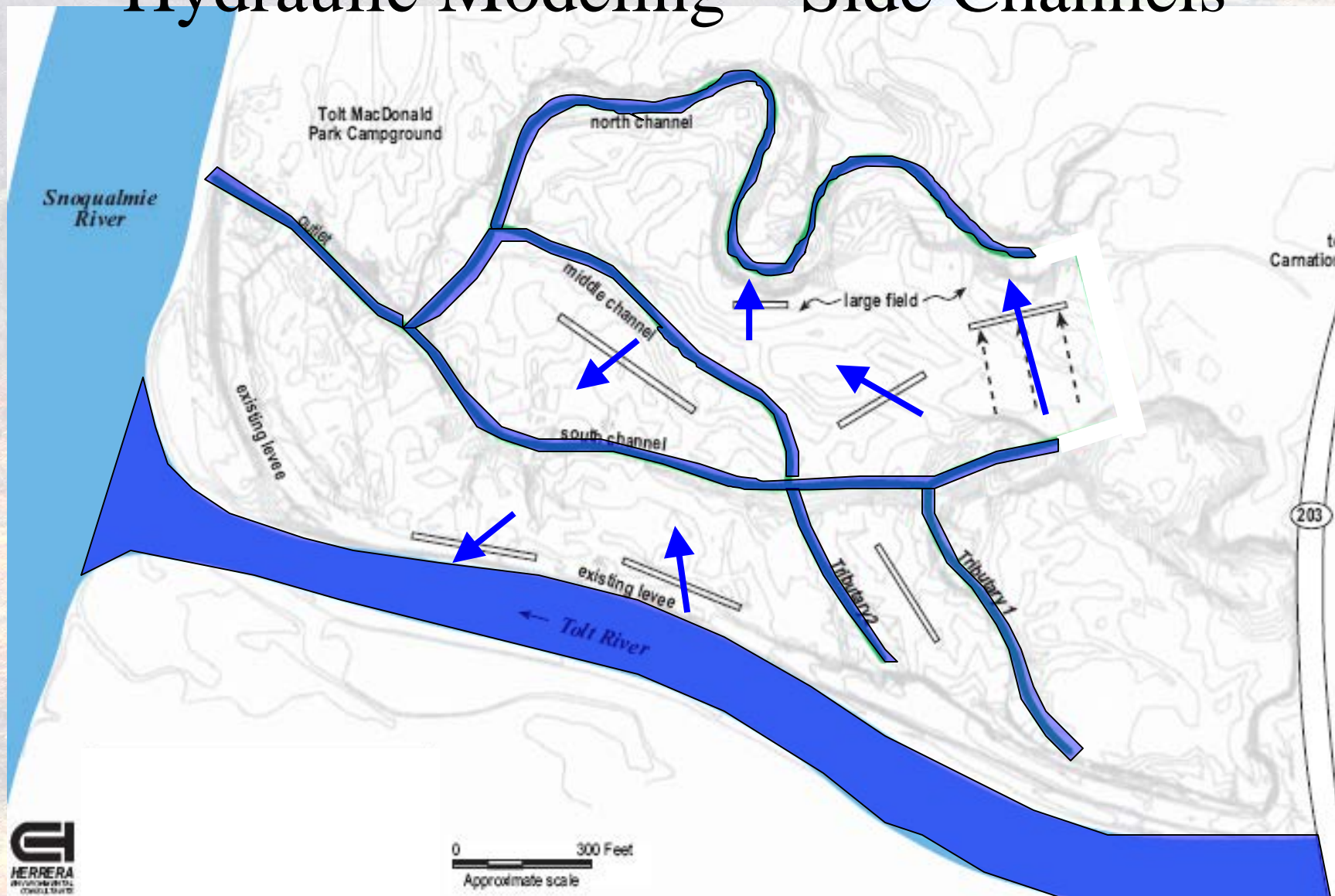




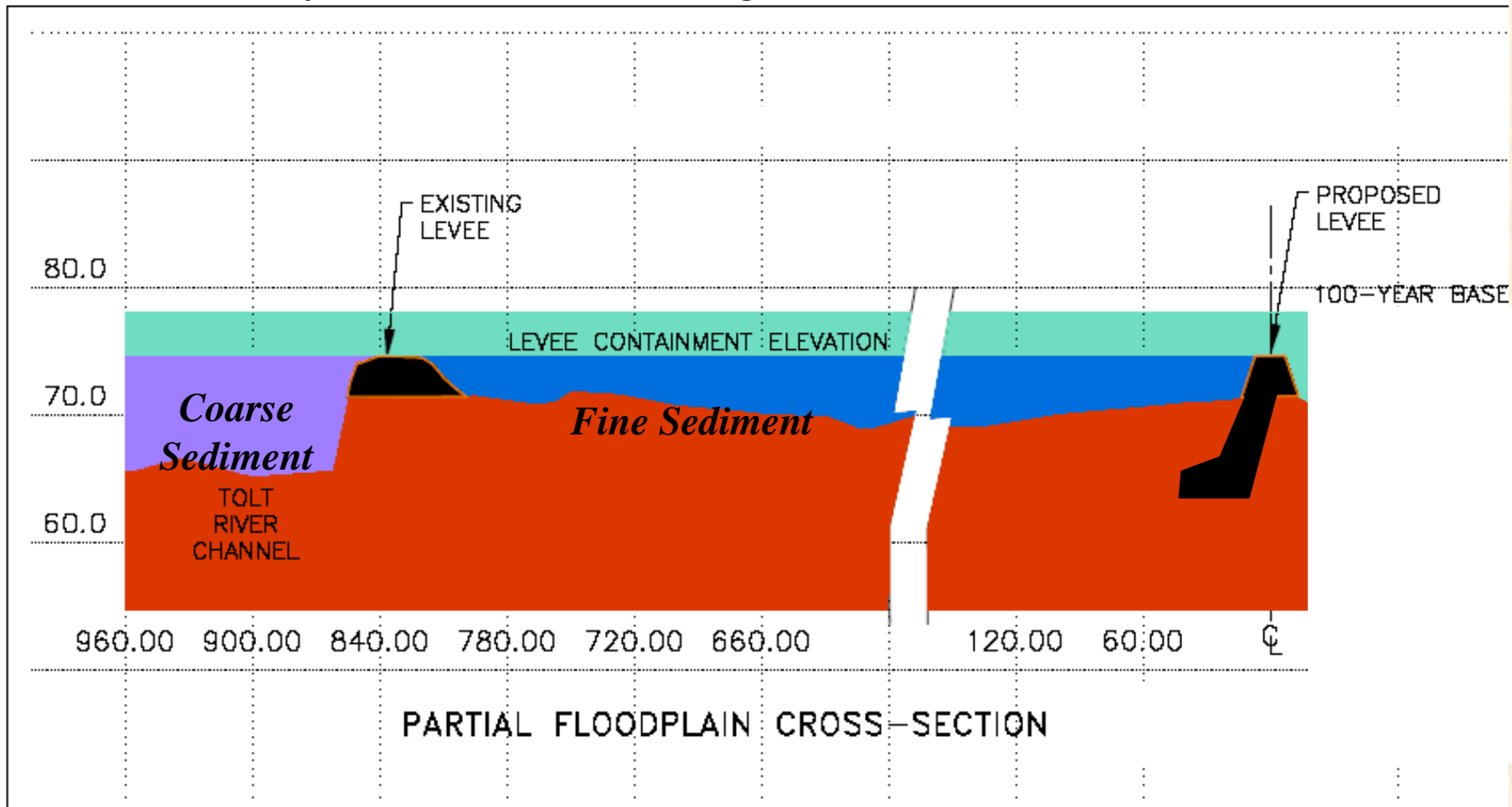
An aerial photograph of a river delta. The river flows from the top right towards the bottom left, forming a wide, meandering channel. The surrounding landscape is a mix of green fields, dense evergreen forests, and areas with autumn-colored trees in shades of orange and yellow. A two-lane road with a double yellow line runs parallel to the riverbank in the foreground. The overall scene is a natural, rural landscape.

Floodplain Reconnection of Lower Tolt River Delta

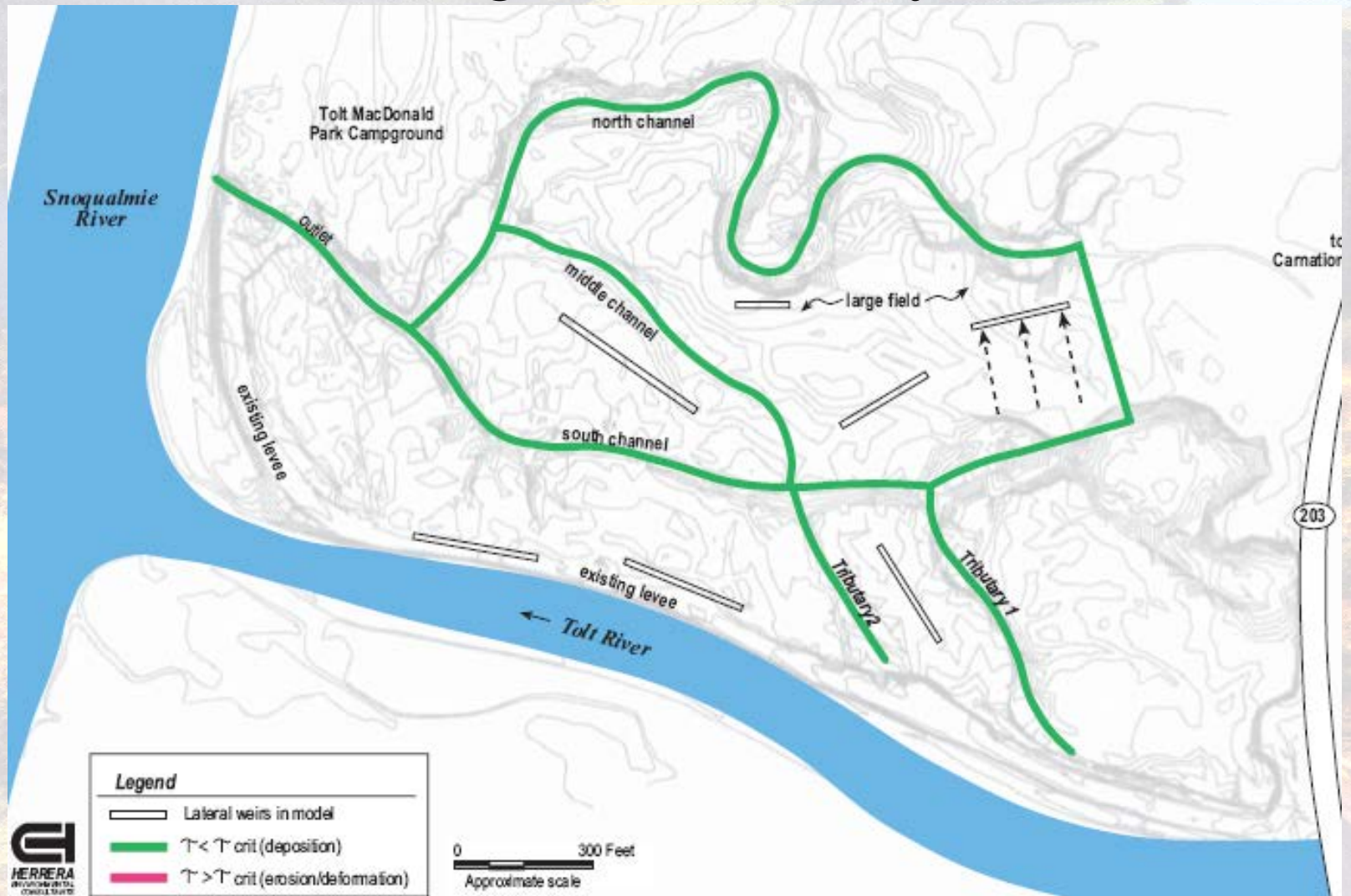
Hydraulic Modeling – Side Channels



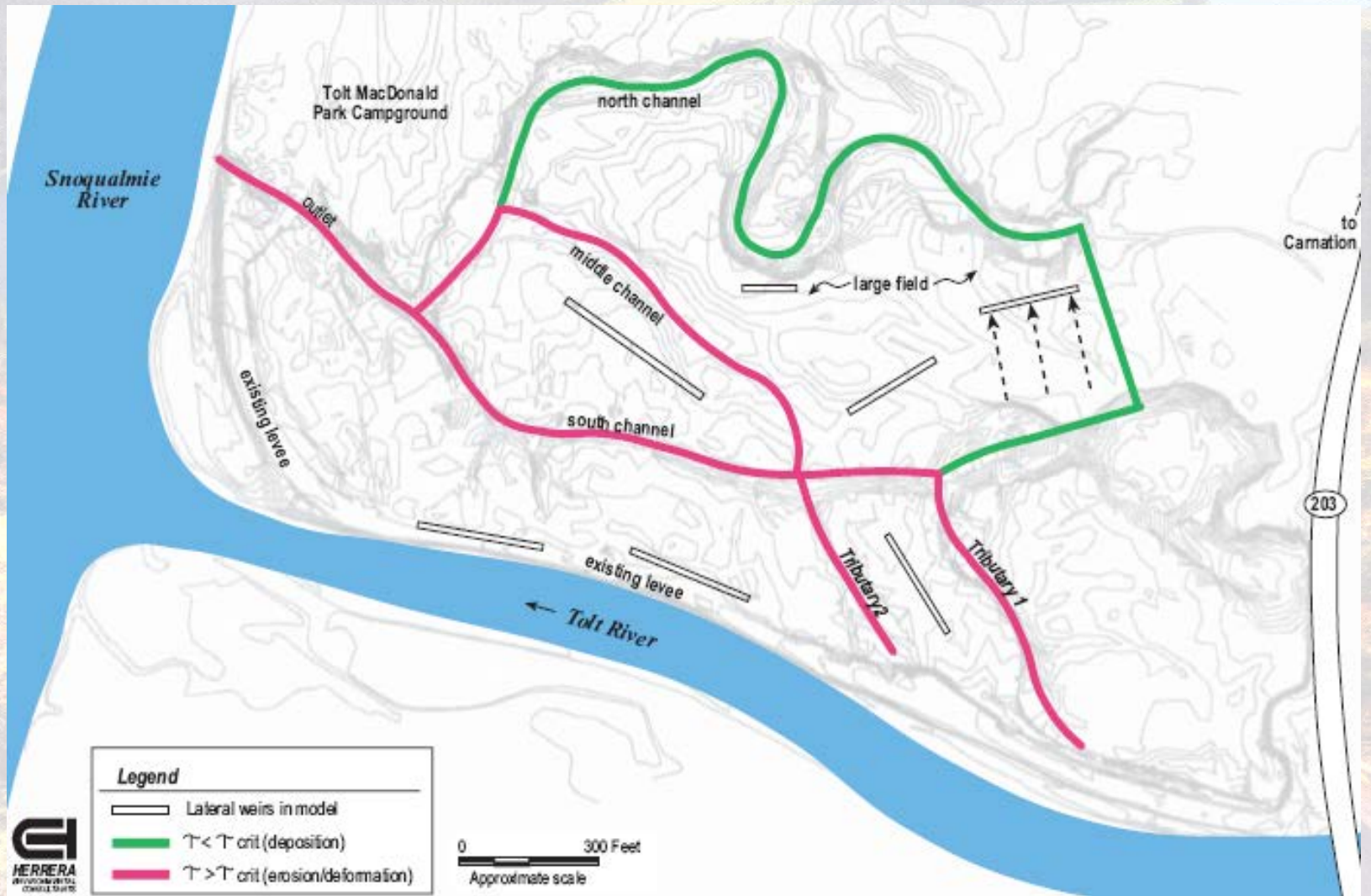
Hydraulic Modeling – Scour and Erosion



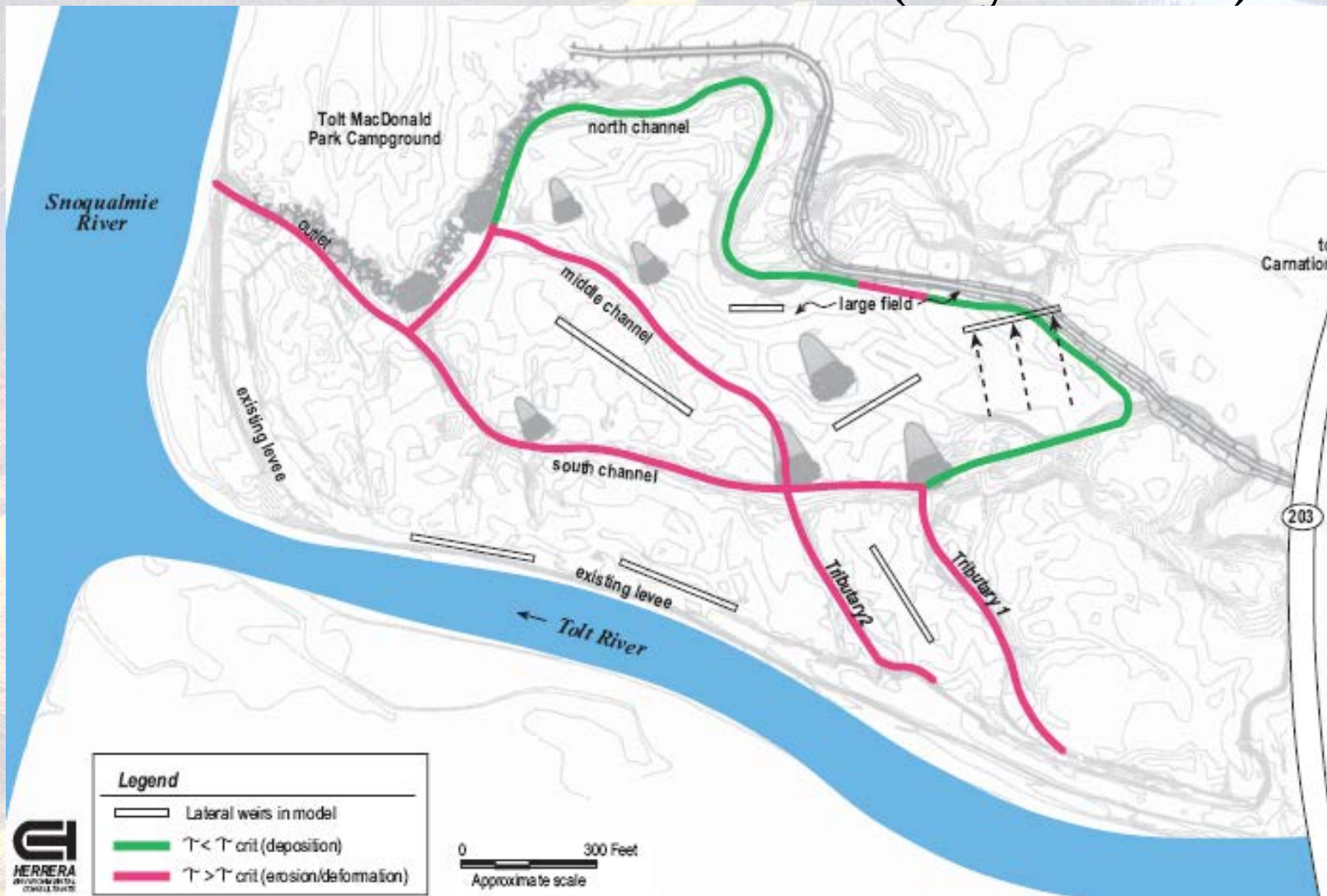
Existing Erosion (2-yr flood)



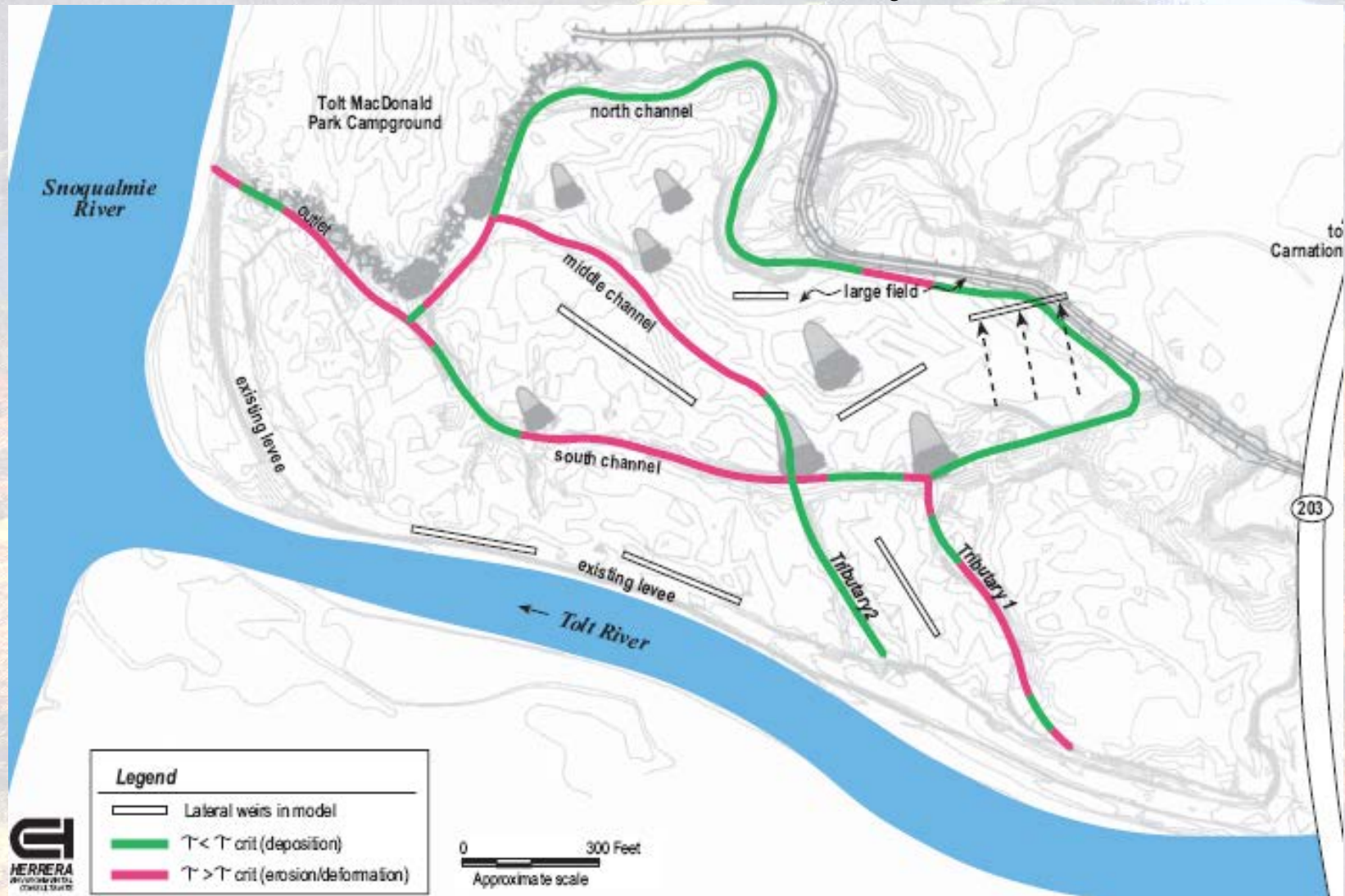
Existing Erosion (10-yr Flood)



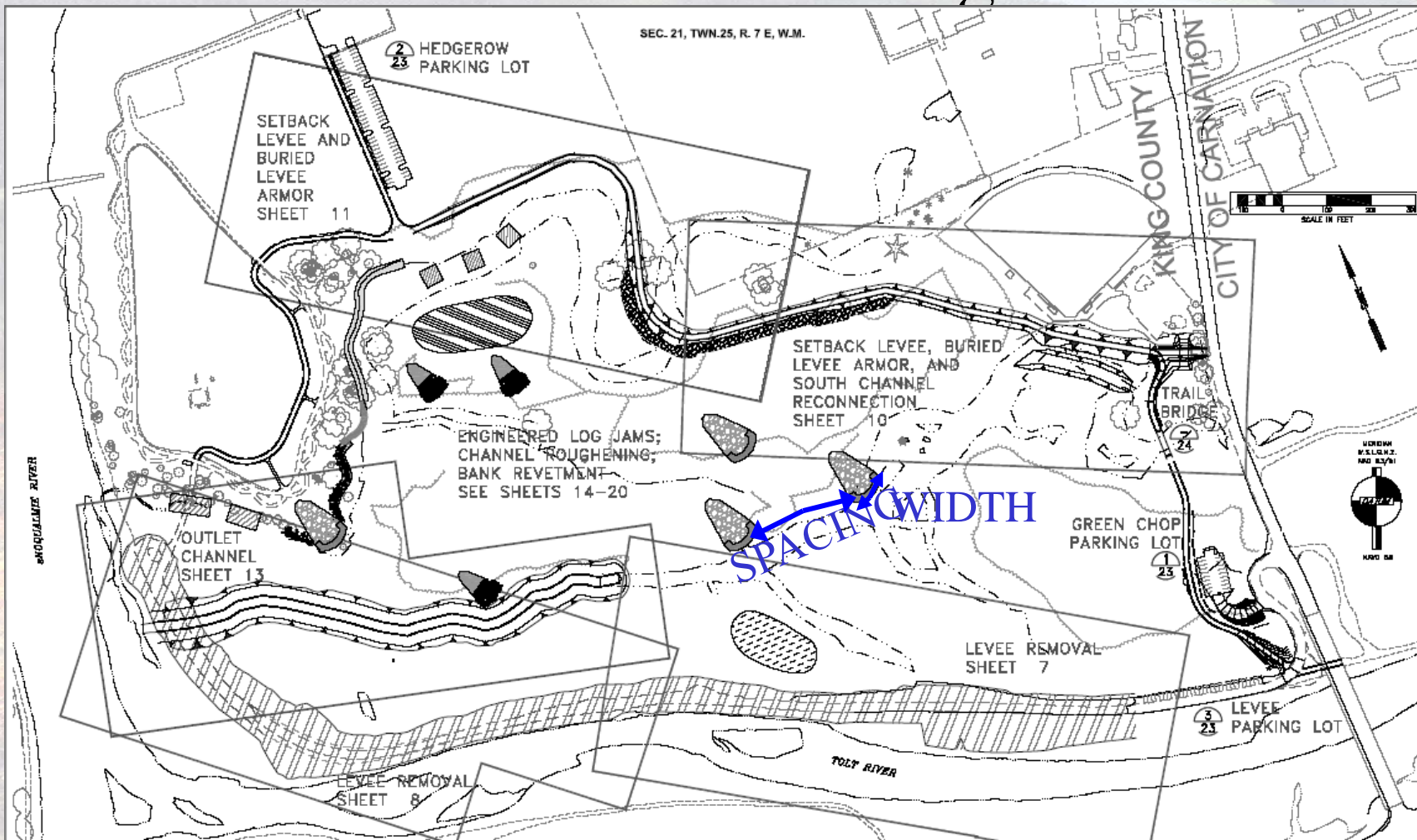
Levee Removal Erosion (2-yr flood)



Erosion over time (10-yr Flood)

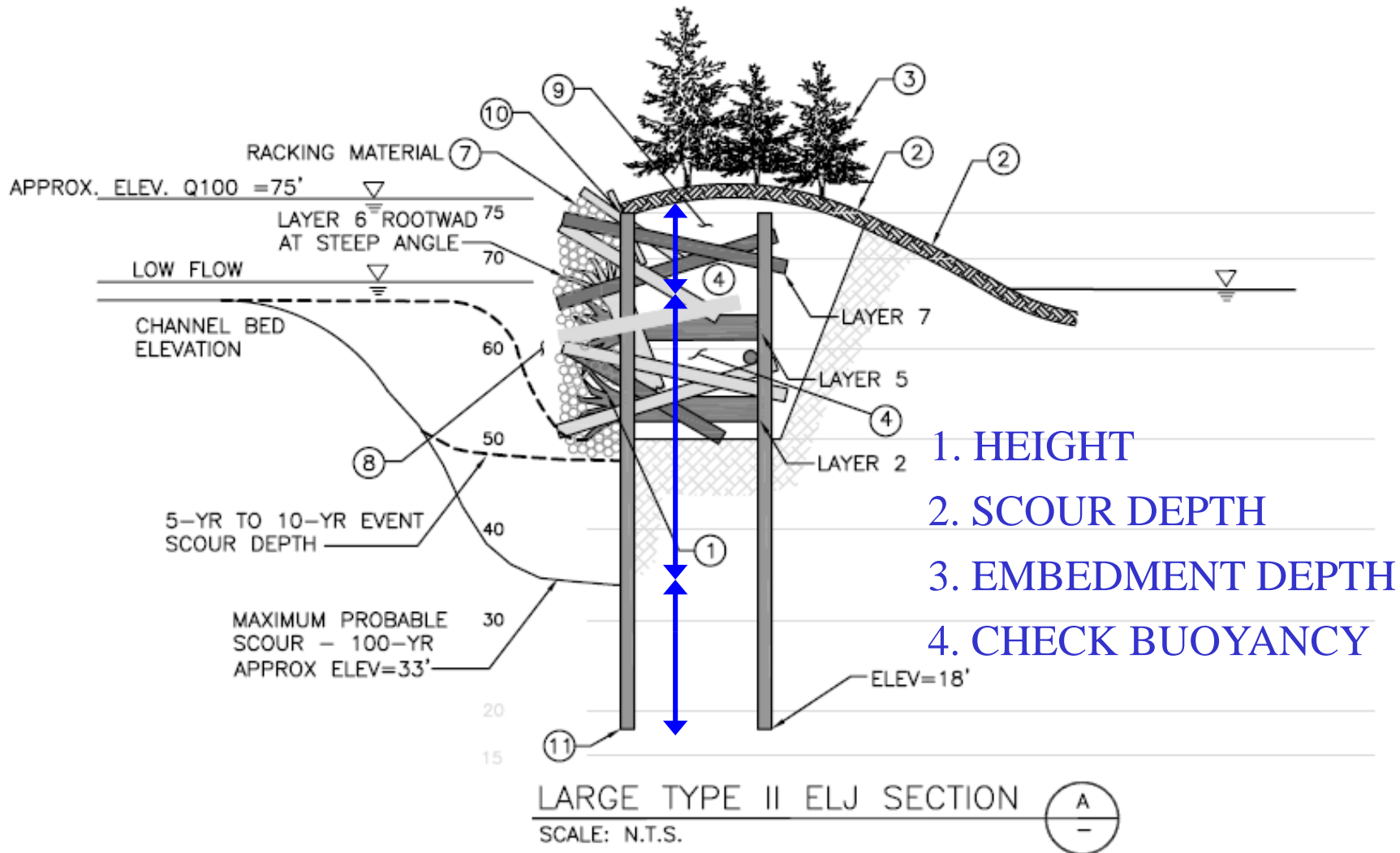


Basis of ELJ Design

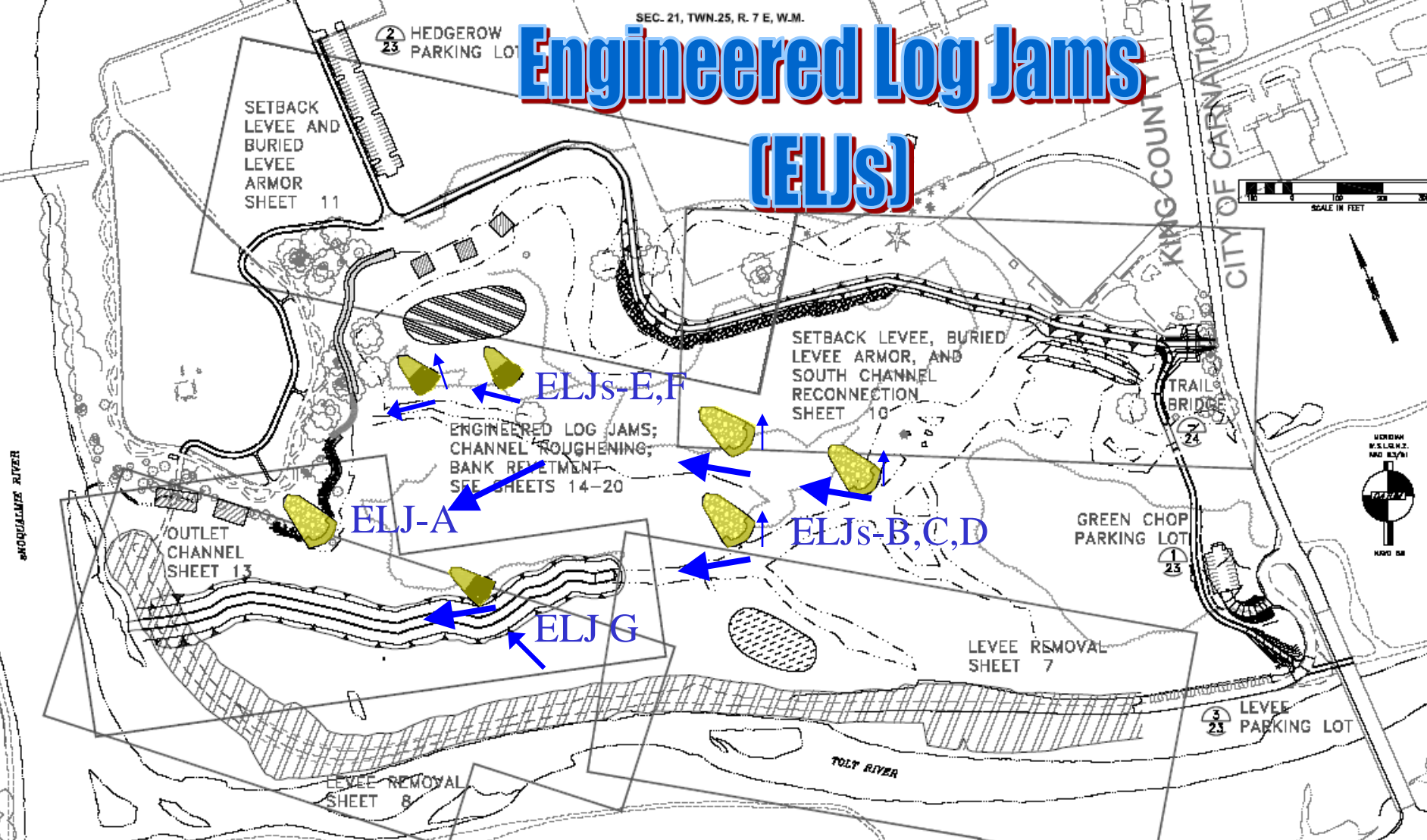


FIELD BOOK: SURVEYED: SPV SURVEY 4/28-7/04 SURVEY BASE: SPV SURVEY/MARINELLA 8/2004 CHECKED: SPV SURVEY/LODGE 8/2004	CADD / 30%	APPROVED: DON ALTHAUSER, P.E. 1/2006 PROJECT SUPERVISOR: DANIE CONDRAMON 1/2006 PROJECT MANAGER: JESSIE RICH, P.E. 1/2006 DESIGNED: BILL MANSFIELD, BRIAN LANGRISH 1/2006 JERRY BUTLER, TONY BEAN 1/2006 JON HANSEN 1/2006 DESIGN CHECKED: J.A. BADELLA 1/2006	FED. AID No. PROJECT No. 021643 SURVEY No. MAINTENANCE DIVISION No. 2		King County Department of Natural Resources and Parks Water and Land Resources Division Capital Projects Section Surface Water - Engineering and Ecological Services Units Pam Rissosavette, Director	LOWER TOLT RIVER FLOODPLAIN RECONNECTION PROJECT OVERVIEW AND SHEET KEY	SHEET 4 OF 29 SHEETS 2004-84
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Basis of ELJ Design



Engineered Log Jams (ELJs)



FIELD BOOK:	
SURVEYED:	SPU SURVEY 4/24-27/04
SURVEY BASED:	SPU SURVEY/ALBANELLA 8/2004
CHECKED:	SPU SURVEY/LODGE 8/2/04

CADD / 30%

REVISED	BY	DATE

APPROVED:	DOAL ALTHAUSER, P.E.	1/2/06
PROJECT SUPERVISOR:	DMARC CONNORSON	1/2/06
PROJECT MANAGER:	PAOLO RIVER, P.E.	1/2/06
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	TERRY BUTLER, TOM BERN	1/2/06
	JON HANSEN	1/2/06
	JAN RADELLA	1/2/06
DESIGN CHECKED:	J. RADELLA	1/2/06

FED. AID No.	
PROJECT No.	021643
SURVEY No.	
MAINTENANCE DIVISION No.	2



King County
 Department of Natural Resources and Parks
 Water and Land Resources Division
 Capital Projects Section
 Surface Water - Engineering and Ecological Services Unit
 Pam Biscione, Director

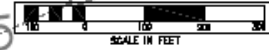
LOWER TOLT RIVER FLOODPLAIN RECONNECTION PROJECT
 SHEET KEY

SHEET 4 OF 29 SHEETS
 2004-84

2
23 HEDGEROW
PARKING LOT

Campground Revetment

ARMOR
SHEET 11



Bank
Reinforcement
Revetment 1

SETBACK LEVEE, BURIED
LEVEE ARMOR, AND
SOUTH CHANNEL
RECONNECTION
SHEET 10

ENGINEERED LOG JAMS;
CHANNEL ROUGHENING;
BANK REVETMENT—
SEE SHEETS 14-20

TRAILS
BRIDGE

GREEN CHOP
PARKING LOT

OUTLET
CHANNEL
SHEET 13

LEVEE REMOVAL
SHEET 7

LEVEE
PARKING LOT

LEVEE REMOVAL
SHEET 8

TOLT RIVER



FIELD BOOK:	
SURVEYED:	SFU SURVEY 4/04-7/04
SURVEY BASE:	SFU SURVEY/MADRELLA 8/2004
CHECKED:	SFU SURVEY/LODGE 8/2/04

CADD / 30%

APPROVED:	DON ALTHOFFER, P.E.	1/2/06
PROJECT SUPERVISOR:	DAVE COOKMAN	1/2/06
PROJECT MANAGER:	ZACH RYAN, P.E.	1/2/06
DESIGNED BY:	MILL WANSFIELD, BRIAN LANDAU	1/2/06
	JERRY BUDER, TOM BEAN	1/2/06
	JON HANSEN	1/2/06
DESIGN CHECKED BY:	J.A. BADELLA	1/2/06

FED. AID No.	
PROJECT No.	021643
SURVEY No.	
MAINTENANCE DIVISION No.	2

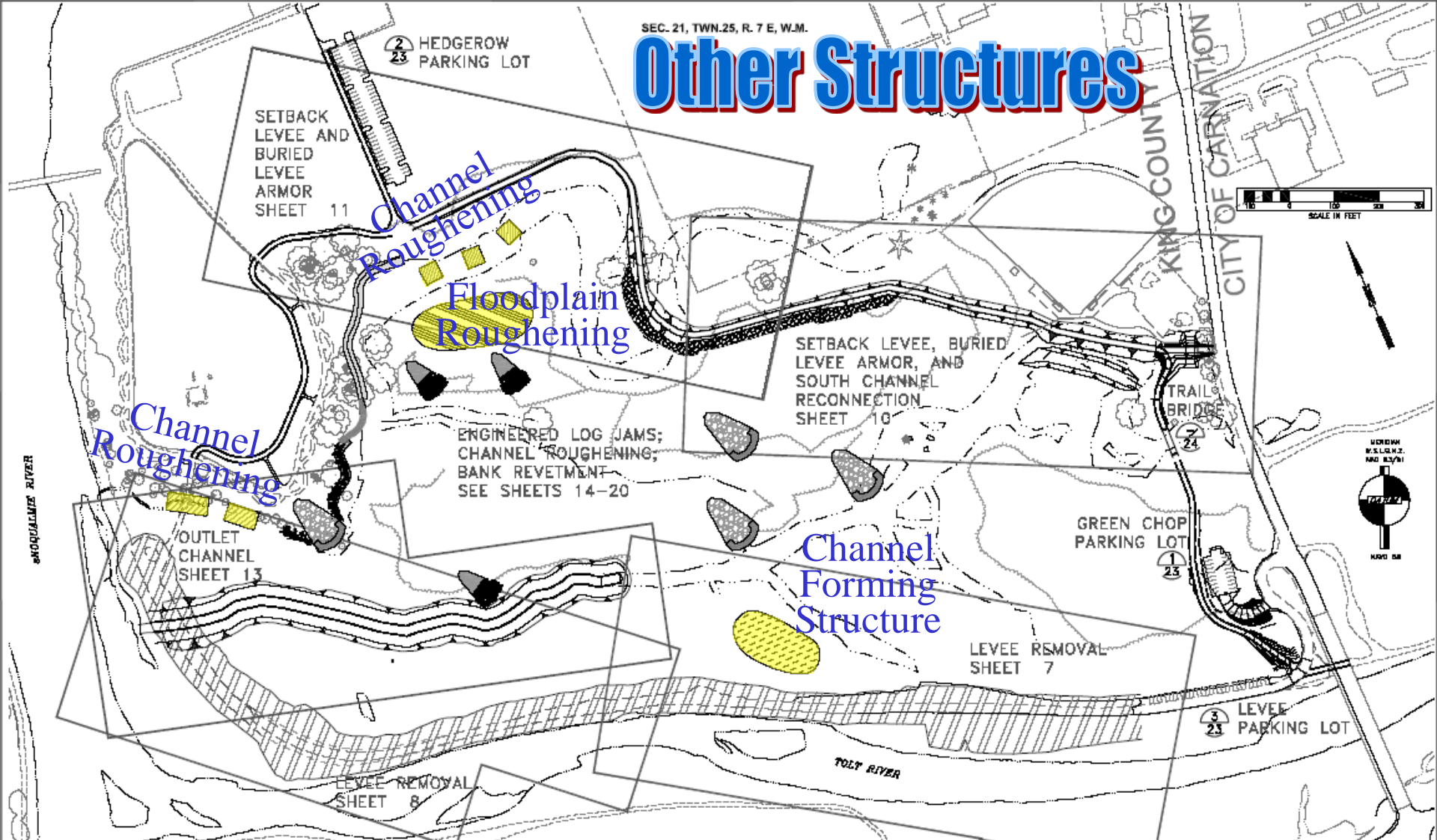


King County
Department of Natural Resources and Parks
Water and Land Resources Division
Capital Projects Section
Surface Water - Engineering and
Ecological Services Unit
Pam Bissonette, Director

**LOWER TOLT RIVER
FLOODPLAIN RECONNECTION
PROJECT**
**OVERVIEW AND
SHEET KEY**

SHEET
4
OF
29
SHEETS
2004-04

Other Structures



FIELD BOOK:		APPROVED: DONALD ALTHAUSER, P.E.	1/2/2006	FED. AID No.			King County Department of Natural Resources and Parks Water and Land Resources Division Capital Projects Section Surface Water - Engineering and Ecological Services Unit Pam Blascovich, Director	LOWER TOLT RIVER FLOODPLAIN RECONNECTION PROJECT CHEWEN AND SHEET KEY	SHEET 4 OF 29 SHEETS 2004-84
SURVEYED: SPU SURVEY	4/24-7/04	PROJECT SUPERVISOR: DAVID COOKMAN	1/2/2006	PROJECT No.	021643				
SURVEY BASE: SPU SURVEY/ALBARELLA	8/2004	PROJECT MANAGER: DAVID RYAN, P.E.	1/2/2006	SURVEY No.					
CHECKED: SPU SURVEY/ALBARELLA	8/2/04	DESIGNED: MILL WAINFIELD, BRIAN LANDAU	1/2/2006	MAINTENANCE DIVISION No.	2				
		TERRY BUTLER, TOM BERN	1/2/2006						
DATE:		JON HANSEN	1/2/2006						
REVISION:		DESIGN CHECKED: M. RADELLA	1/2/2006						

CADD / 30%



**Mendenhall River, Juneau, Alaska:
A simple log crib revetment**

Complex ELJ Bank Crib – Mendenhall River, Juneau, Alaska, 2006



Complex ELJ Bank Crib – Mendenhall River, Juneau, Alaska, 2006



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