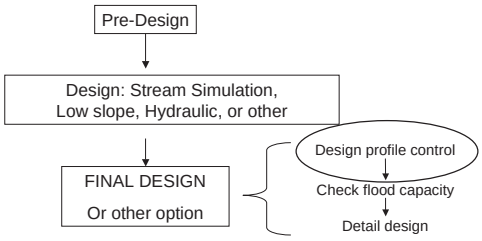
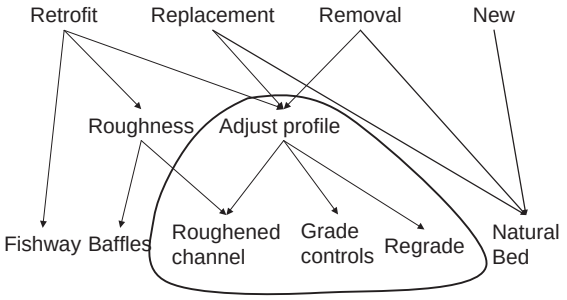
Final Design



1

Profile Control

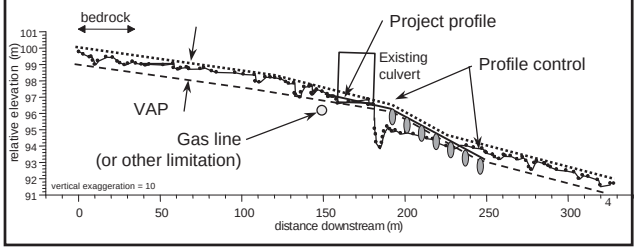
Culvert Design for Fish Passage



3

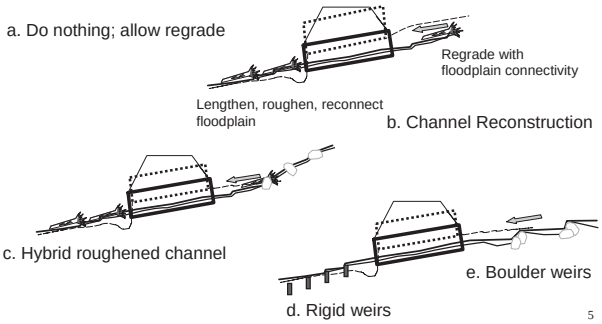
Newbury Creek Project Profile
With a forced profile

Scenario C:
Regional incision.
Forced profile necessary.



4

Profile control options



5

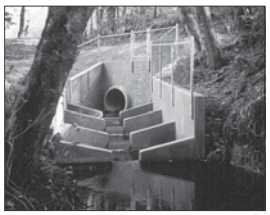
Profile control options

	Slope	Pros / Cons
Fishway	10% or "vertical"	+ Small footprint - Species, flow, sediment, debris
Log sills	5%	+ Rigid, durable - Species, habitat
Roughened channel	Durability, bedload limit	+ Passage diversity - Species, failure risk
Boulder controls	5% (+)	+ Passage diversity, Habitat - Failure risk
Channel restoration	Limited by channel type	+ Passage diversity, Habitat - Scale
Regrade	?	- Regrade risk, time to restore
Do Nothing		

6

Fishways

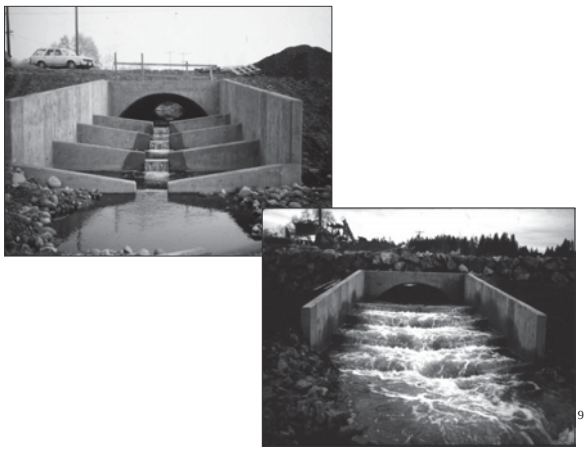
- Pool and weir styles typically used downstream of culverts.
- Passage behavior by species; leaping, swimming
- Criteria
  - Step height, step shape
  - energy dissipation - limits flow range
- Debris, sediment maintenance



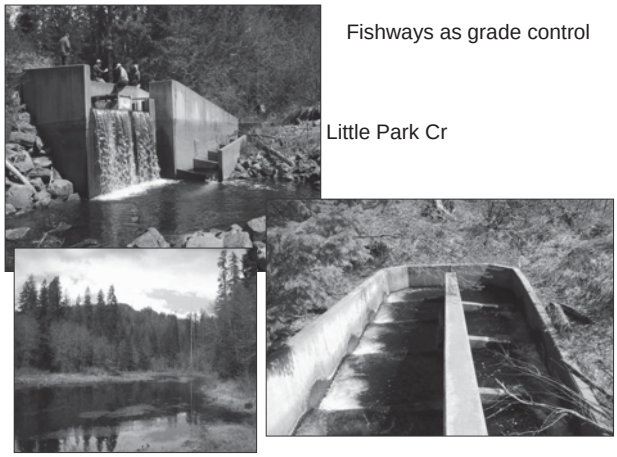
7

Fishways

- Objectives:
  - Steepen grade
  - Rigid permanent bed control
  - Optimize passage for target species, not diverse
- Narrow flow range
- 10% grade max in small channels. Bypass fishways "vertical"
- Minimum footprint
- High construction, operation, maintenance cost
- Designs available



9

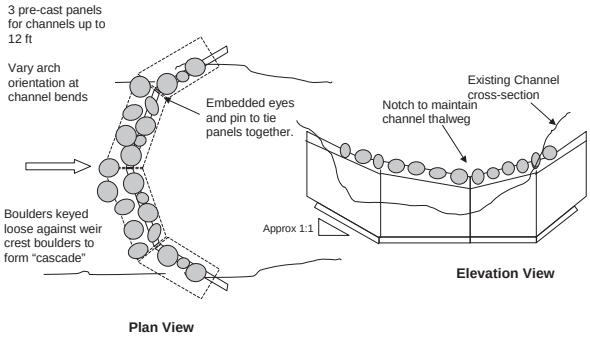


Fishways as grade control

Little Park Cr

Concrete, sheet pile, …

- Objectives:
  - Steepen grade
  - Rigid permanent bed control to maintain steep grade
- Less than 5% grade max in streams
- Designs available
- Prefabricated; installation easy but demands care
- Shape to fit channel and control thalweg
- Built-in abutments, energy dissipation, cutoff, crest shape

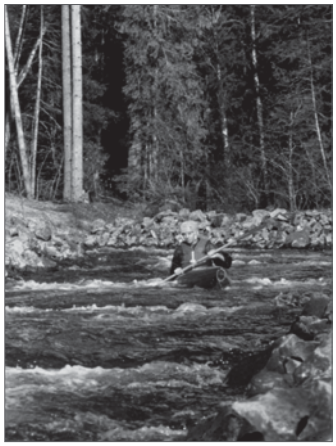


Modular Arch Drop Structure

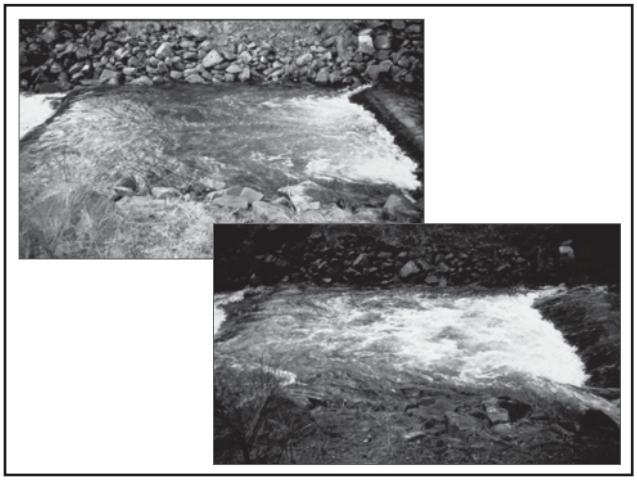
12

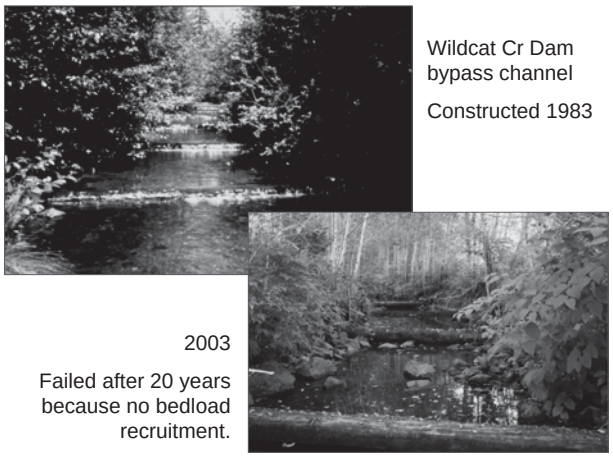
Wildcat Cr Dam
bypass channel

Constructed 1983



15





Wildcat Cr Dam bypass channel

Constructed 1983

2003

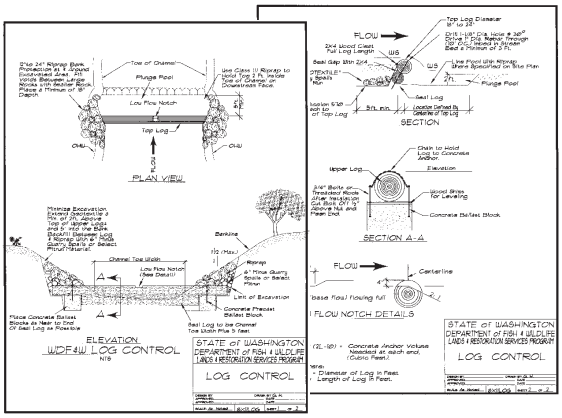
Failed after 20 years because no bedload recruitment.

Three keys to stability

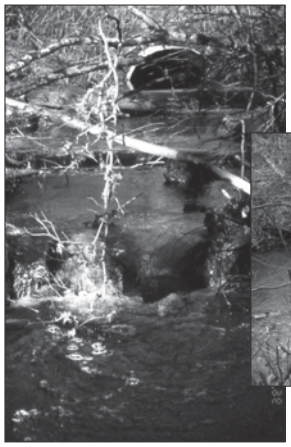
1. Double log
2. Tiedown
3. Ballast

Bank failure

Log control structurally sound



http://www.wa.gov/wdfw/hab/engineer/cm/culvert_manual_final.pdf

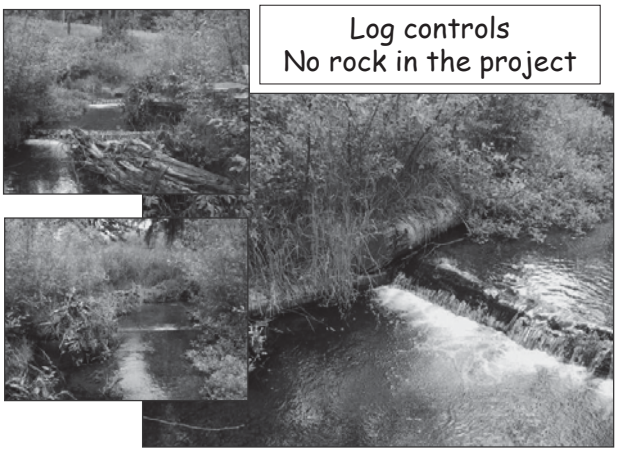


Index Creek
Vee log weirs

Physt R. trib

"X-weirs"

21



Log controls
No rock in the project

Log controls

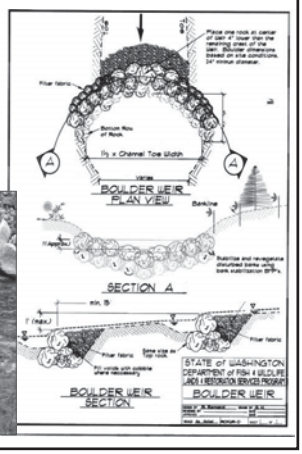
- Straight
  - Objective: Steepen grade, optimize select passage, minimize cost and length, secure elevation control
  - 5% grade max as bed retention
  - Uniform channel
  - Secure designs available
- Vee log
  - Objective: Steepen grade, deepen thalweg, narrow channel, provide select passage
  - More diverse channel
- Can be made complex
- Durable

23

Boulder Weirs

- Details
  - Select materials, construct arch, use footer rocks, key individual rocks
  - Careful construction and supervision necessary
- Good option for upstream "flexible" control
  - 5% grade max in small channels
  - Designs available
- Easily adjusted
- Maintains channel shape
- Cascading failure possible

Boulder weirs



26

Great Brook waterline before

With boulder weirs

28

Barnard - WDFW

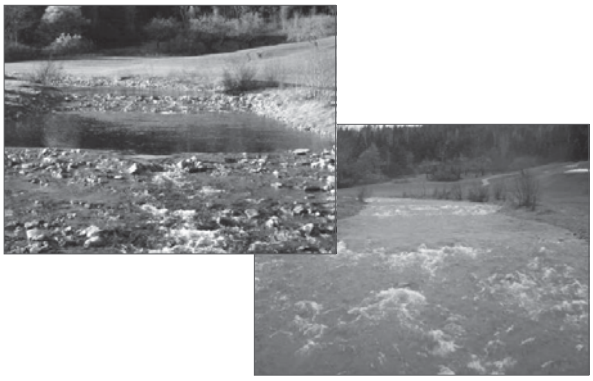
Cedar Creek rock vees for bed retention

Chutes

Spring Prairie Cr
Cobble riffle

30

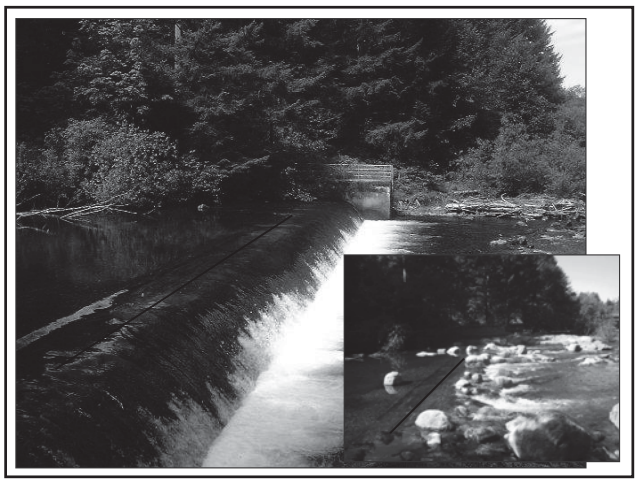
Luther Aadland

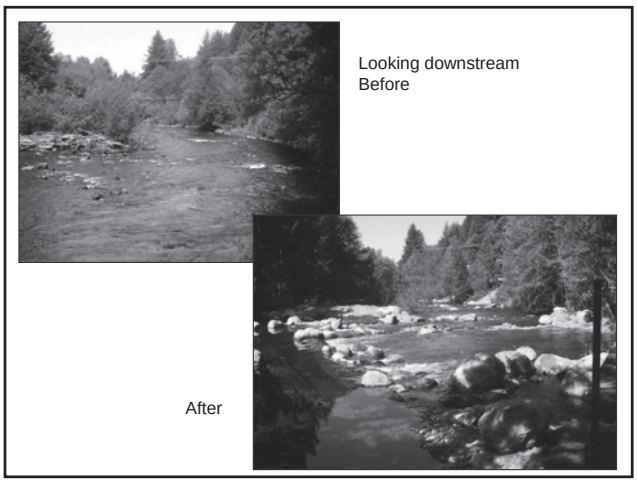


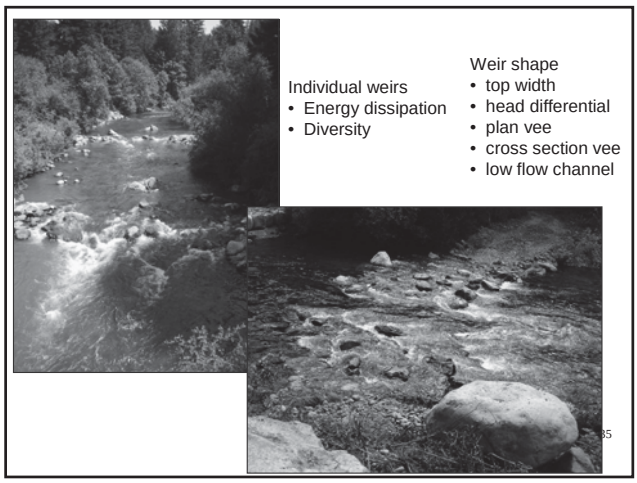
31

Design: Robert Newbury
Photo: Jane Watts, Fundy NP

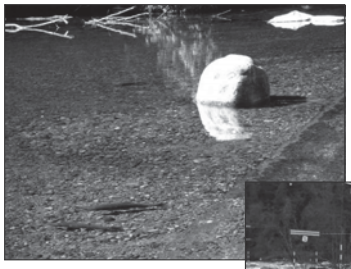
32




Looking downstream
Before
After


Individual weirs
• Energy dissipation
• Diversity
Weir shape
• top width
• head differential
• plan vee
• cross section vee
• low flow channel
35


Critical construction supervision
36



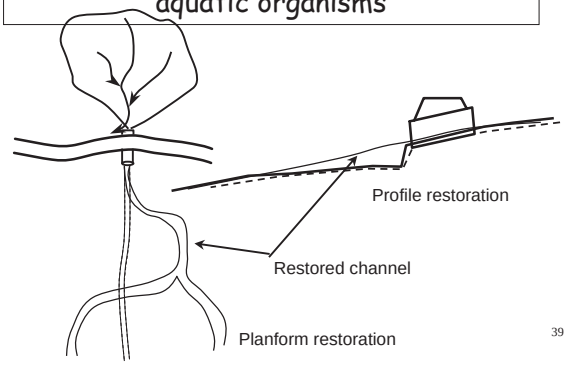
First fish passage since 1900

and four months later…

Boulder weirs and chutes

- Boulder weirs
  - Select materials, construct arch, use footer rocks, key individual rocks
  - Careful construction and supervision necessary
  - Less than 5% grade max in small channels
  - Easily adjusted
  - Cascading failure possible
- Chutes
  - Low to moderate slope
- Good option for upstream "flexible" control
- Maintain channel shape
- Designs available

Channel restoration for passage of aquatic organisms



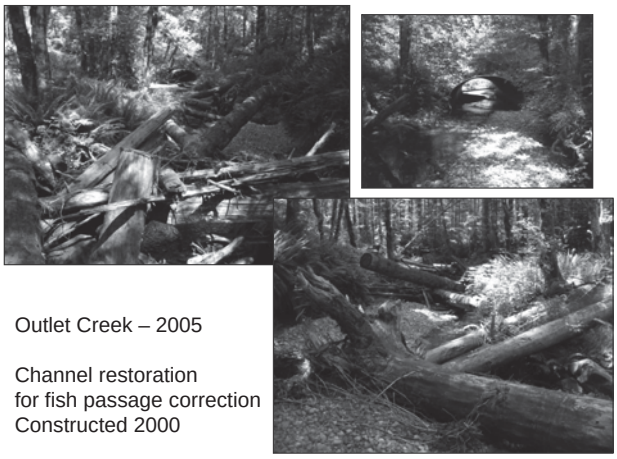
39

Outlet Creek – 2005

Upstream channel

Downstream channel incised

40



Outlet Creek – 2005

Channel restoration
for fish passage correction
Constructed 2000

Channel restoration
for fish passage correction

Reference Channel

O'Grady Cr – 2002

Stream Simulation

Channel restoration

- Objective:
  - Steepen grade
  - Optimize passage
  - Restore habitat
- Design natural channel as full stream simulation project
- High cost and project length
- Max slope is function of channel width and passage objectives

43

Final Design

Pre-Design

↓

Design: Stream Simulation,
Low slope, Hydraulic, or other

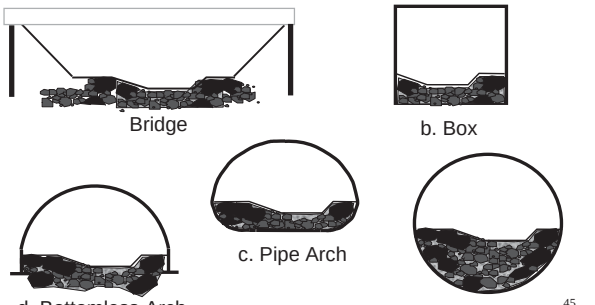
↓

FINAL DESIGN
Or other option

Design profile control
↓
Check flood capacity
↓
Detail design

44

Stream simulation regardless of type of structure



45

Bottomless compared to pipe

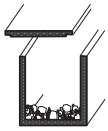
Bottomless

- Can be placed over existing streambed or top loaded
- Can be placed over bedrock
- Footings can be shaped to bedrock.
- Concrete stemwall provides durability against abrasion and corrosion
- Construction duration increased by cast-in-place concrete
- High shear strength of bed reduces risk of bed failure
- Compaction easier without round shape

46

Pipe compared to bottomless

Pipe



- Pre-assembled pipe greatly reduces time for construction
- Structure not vulnerable to scour and headcut
- No measures needed to protect stream from fresh concrete
- Less costly and complex construction and less risk of error because no concrete footing
- Shape may allow narrower excavation
- Higher load capacity in poor foundation soils

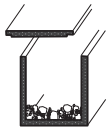
47

Considerations for Culvert/bridge Type

- Opening size vs. channel stability, horizontal & vertical
- Span existing channel, how far?
  - channel shape, width, and depth
  - confinement – risk of pressurized pipe
- Geology – bedrock and soil foundation characteristics
- Road fill height, culvert cover, loading, right of way
- Durability of structure & life cycle costs,
- Construction – construction time, excavation, dewatering, traffic

48

Other culvert shape and material considerations



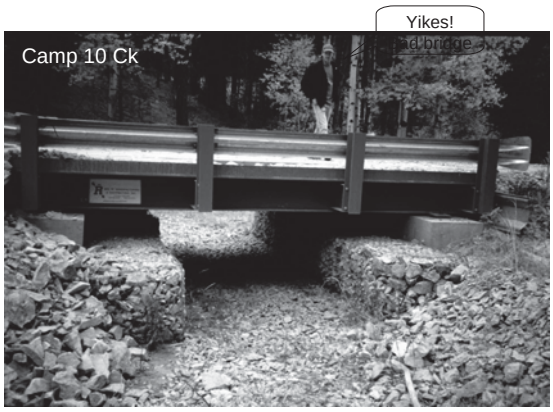
- Prefabricated or precast can be installed as single or few pieces
- Precast box can be top loaded
- Structural plates can be pre-assembled
- Concrete is more durable
- Corrugations have more shear stress
- Compaction of round haunches is difficult

49

Culvert Types - Yea and Nay

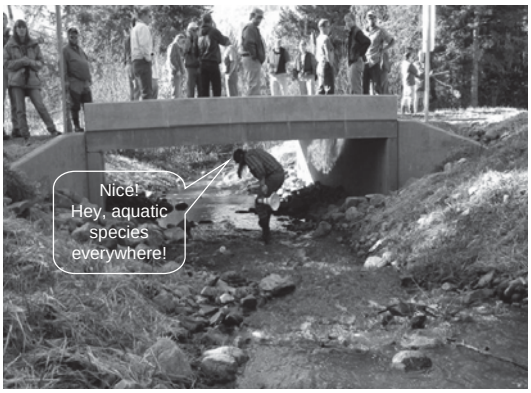
Culvert Type	Advantages	Disadvantages
Box	Prefabricated (concrete) Durability (concrete) Top loaded? (concrete) Backfill compaction easiest Greatest foundation capacity Greater top width at flood flows	Weight (concrete) Bed to structure shear (concrete)
Round	Prefab or Pre-assemble Highest load capacity	Deep excavation for economical width Compaction difficult
Pipe Arch	Prefab or Pre-assemble Low profile; cover and excavation	Narrow range of headroom, bed depth Compaction critical
Bottomless Arch	Place over existing bed Place over bedrock Construct independent footings Degrading channel is structural issue Bed to sub-bed shear strength	Time for construction, fabrication Footing construction often deep and wide Structure vulnerable to scour and headcut

50



Not necessarily better just because it's a bridge.

51



Greater than bankfull

52