Design of Stream-Road Crossings for Aquatic Organism Passage in Vermont

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Culvert Design for Fish Passage

- Retrofit
- Replacement
- Removal
- New

- Roughness
- Adjust profile
- Fishway Baffles
- Roughened channel
- Regrade
- Grade controls
- Natural Bed

Passage Design Process

Pre-Design
- Project Objective
  - Assessment, Suitability
  - Design project long profile and alignment
  - Select design method

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

FINAL DESIGN
Or other option

Project Objectives - What is Success?

- Passage for target species
- Ecological connectivity
- Minimize delay of target species
- Passage for all aquatic organisms
- Low cost
- Block introduced species
- Public safety
- Public education
- Habitat restoration
- Durability
- Habitats restored
- Wildlife passage
- Protected from floods, debris, sediment

Design method determined by project objectives

Project objectives
- Habitat protection, restoration
- River and stream continuity
- Passage of fish
- Passage of other aquatic organisms
- Wildlife passage
- Traffic, road, safety, other
- Funding limits and requirements
- Regulatory

Design methods
- Hydraulic
- Stream Simulation
- Low slope (active channel, No slope)
- Alternative designs

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4 – Culvert Pre-Design
Site Assessment. More on this later.

All design methods
- Longitudinal Profile
- Sketches, photos, topography,
- Cross Sections
- Geo-tech

Stream simulation
- Identify and interpret reference reach
- Substrate
- Bed Structure

Site suitability for culvert

Not suitable for any culvert?
- Unstable channel
- aggrading, alluvial fan, incising
- Debris flows
- Habitat considerations

Habitat considerations at road crossings

- Direct habitat loss
  - Rearing, spawning habitats, food production
  - Mitigation
- Upstream, downstream channel impacts
- Ecological connectivity
  - Other organisms, sizes of fish
  - Debris, sediment, channel processes
  - Floodplain habitats and processes
- Channel maintenance
- Construction impacts, water quality
- Risk of culvert failure, stream diversion

Passage Design Process

Pre-Design
- Project Objective
  - Assessment, Suitability
  - Project Alignment and profile
  - Select design method
- Design: Stream Simulation, No slope, Hydraulic, or other
  - Alignment issues
  - Scour or incision, scale of the problem
  - Variability over time and distance
  - Sensitivity
  - Headcut issues
  - Restoration

Final Design
Or other option

Vertical Adjustment Potential

Alignment

- Concurrent with profile design
- Important factor for debris blockage and failure
- Consider existing and future stream channel.
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Plan view - three culvert alignment options on skew

- a. Culvert on stream alignment
- b. Realign stream to minimize culvert length
- c. Widen and/or shorten culvert
- Realigned channel
- Skew
- Headwalls

Plan view - three culvert alignment options on bend

- a. Culvert on stream alignment
- b. Realign stream to remove bend
- c. Widen and/or shorten culvert to preserve bend
- Realigned channel
- Headwalls
- Skew
- d. Relocate

Transitions

- Hamilton, Ohio
  - 42' span, 19' rise on natural stream alignment (Contech)

- North Carolina
  - (Con-Span)

Hourglass syndrome

- Restore upstream alignment and transition to remove backwater scour and restore sediment and bed material transport.

Restore downstream banks for stability and continuous banklines?

Project Profile

- Project profile is what is actually constructed
- Start with initial vertical adjustment potential from site assessment
- Consider profile and alignment issues concurrently
- Consider headcut issues
- A forced profile might be necessary
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**Estimate channel adjustments for life of project**

- Stable channel with variability
- Unstable channel

**Profile Variability and Sensitivity**

Profile punctuated by diversity

**Case #1: Scour Pool**

- Natural Channel Grade
- Solution is short

**Case #2: Incised Channel**

- Natural Channel Grade
- Incised Channel Grade
- Headcut

**Newbury Creek Project Profile**

- Vertical adjustment potential – possible upper limit (aggradation)
- Vertical adjustment potential – lower limit (degradation)

**Scenario A:**
- Profile from site assessment
- Bed to be constructed
- Consider alignment, profile issues
- Within VAP and +/- parallel
- Max pool depth above VAP
- Tie to existing channel

**Scenario B:**
- Regional incision.
- Vertical adjustment potential assumes no culvert.
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**Newbury Creek Project Profile**
With a forced profile

Scenario C:
Regional incision. Forced profile necessary.

**Jones Creek**
From downstream

Any problem here?

**Rate of Channel Adjustment**

1979 – Siegel Ck, LNF
1988 – Siegel Ck, LNF

**Channel regrade considerations - 1**

- Extent and evolution of regrade expected
- Adjacent channel
  - Upstream banks – stability, riparian, impounded wetlands?
  - Is there value of culvert as nick point? Habitat, infrastructure

**Foster Cr**
Clackamas County 2001

Jones Creek upstream
Inlet Control
Backwater deposition

Culvert outlet plunge

**Incised channel**

Project Profile?
Channel regrade considerations - 2

- Bed material
  - Backwater wedge?
  - Potential bedrock exposure?
  - Protect existing armored bed

Channel regrade considerations - 3

- Culvert and channel capacity with sediment slug
- Potential passage barriers created upstream
- Construction access to build regrade
- Opportunities for channel restoration downstream

Outlet Creek – 2005
Upstream channel
Downstream channel incised

Road Impounded Wetland

- High or clogged culvert causes permanent backwater
- Elevated water surface and wetland
- Perched culvert
- Sediment deposit
- Previous stream gradient

Headcut issues – Sediment slug
Downstream channel overwhelmed by sediment slug from headcut

Headcut issues
Bed material
Wyonochee trib - 1983
Culvert replaced
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