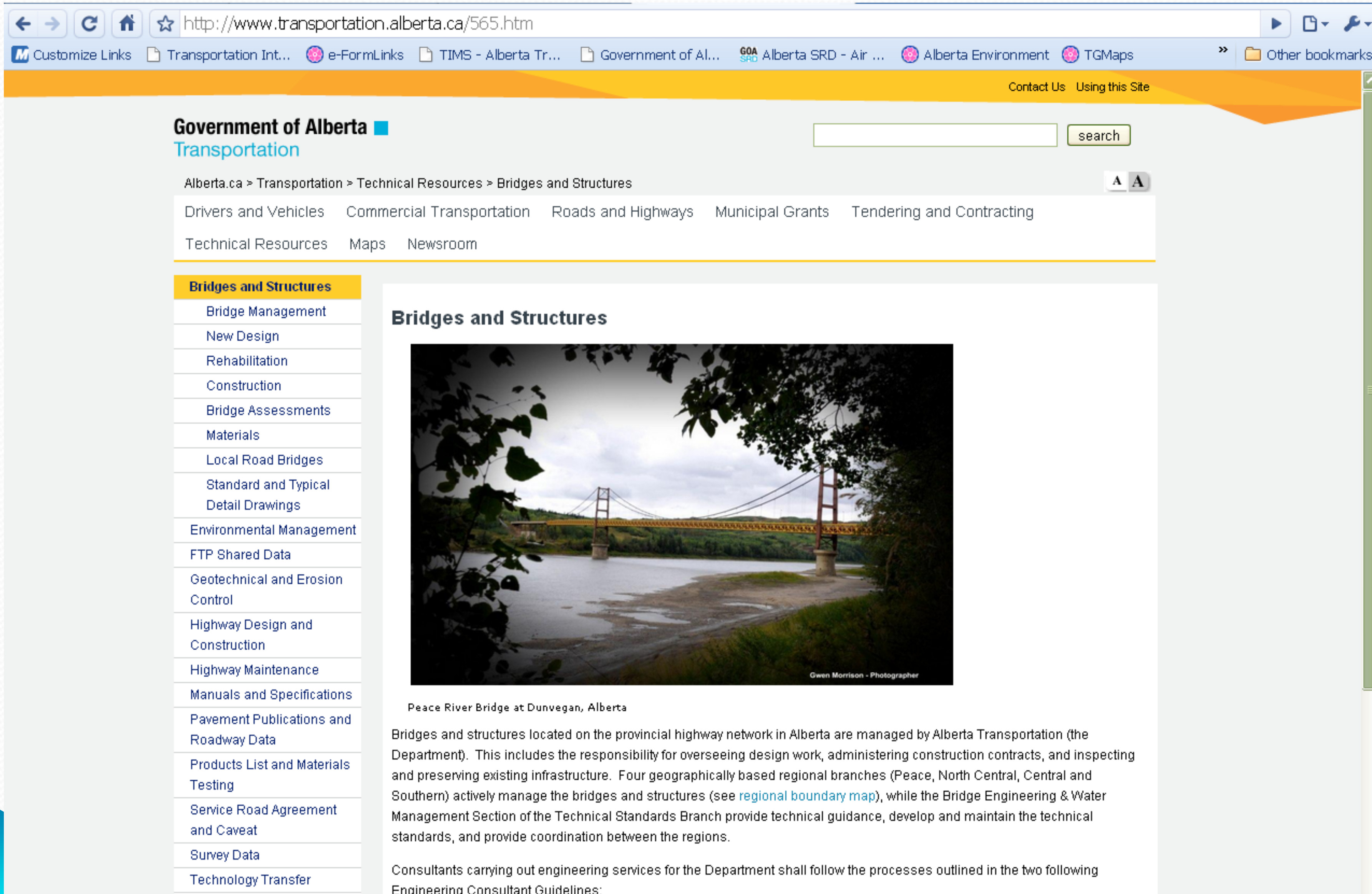
Bridge Planning Updates

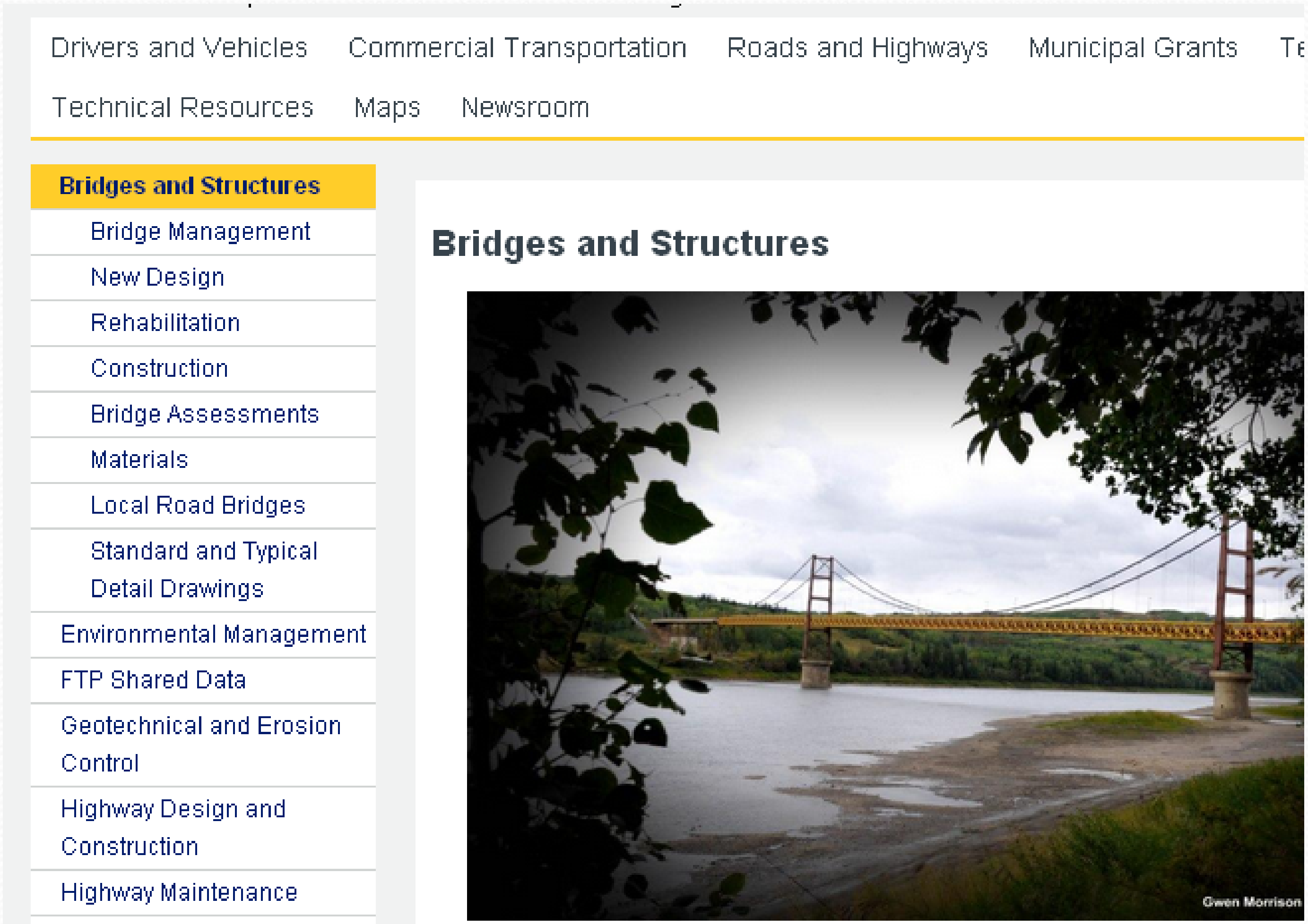
Bridge Planning Practitioners Workshop

April 2012

Bridge Website



Bridge Website



Bridge Website

Bridges and Structures

New Design – Bridge Planning

The Department places great value on the Bridge Planning phase of projects. The goal of this phase is to optimize the bridge location and geometry. This phase requires a working knowledge and a balanced integration of the following issues:

- roadway geometrics (commentary);
- roadside design;
- stream hydrotechnical characteristics;
- geotechnical conditions;
- structure considerations (commentary);
- bridge safety, operation and maintenance concerns;
- survey;
- land use and access management;
- utilities;
- pedestrian and cyclist considerations;
- railway considerations;
- economic and risk assessments;
- environmental constraints; and
- site specific history and site constraints (commentary).

A Bridge Design Process Chart is available in Appendix J1 of the Engineering Consultants Guidelines and identifies how bridge planning fits into the overall bridge design process.

Bridge Planning Conceptual Design involves the integration and optimization of the roadway design standards and best practices with the bridge. Specifically it considers the horizontal and vertical alignments, the extent of the bridge fills, river protection works and possible bridge structure geometry. Further guidance is provided at the following link:

- Bridge Planning Conceptual Design

Bridge Planning Hydrotechnical Design involves the determination of the channel characteristics, and estimation of the hydrotechnical design parameters for a site. The estimations are used for setting the minimum bridge elevation and the riprap design for the site. Further guidance is provided at the following link:

- Bridge Planning Hydrotechnical

The following additional links are available:

- Design Guidelines for Bridge Size Culverts
- Railway Grade Separations – Application Guidelines Overview

Bridge Website

- Bridges and Structures
  - Bridge Management
  - New Design
  - Rehabilitation
  - Construction
  - Bridge Assessments
  - Materials
  - Local Road Bridges
  - Standard and Typical Detail Drawings
- Environmental Management
- FTP Shared Data
- Geotechnical and Erosion Control
- Highway Design and Construction
- Highway Maintenance
- Manuals and Specifications
- Pavement Publications and Roadway Data
- Products List and Materials Testing
- Service Road Agreement and Caveat
- Survey Data
- Technology Transfer
- Traffic Control & Signs
- Traffic Counts
- Water Management

About Us

Bridges and Structures

New Design – Bridge Planning Hydrotechnical Design

Bridge Planning Hydrotechnical Design involves the determination of the channel characteristics, and an estimation of the hydrotechnical design parameters for a site. These estimations are used for setting the minimum bridge girder flange elevation, culvert sizing and the riprap design for the site.

Hydrotechnical Design documents applied during the design of the Department's bridges, culverts and stream encroachments are summarized below. The Environmental Management section may contain useful references when dealing with regulatory authorities during design.

- Hydrotechnical Design Guidelines for Stream Crossings – provides guidance on the determination of design flow parameters (Y,V,Q) for stream crossings.
- AT Bridge and Culvert Hydraulics Guide – discusses hydraulic modeling approach; river engineering issues including scour, ice and drift.
- Culvert Sizing Considerations – discusses the optimization of culvert design based on a variety of considerations including but not limited to flooding impacts, fish passage and protection works.

Hydrotechnical Reference Documents are also available. Documents of particular interest include:

- Context of Extreme Floods in Alberta - the basis for the Department's approach to design flow determination.
- Evaluation of Open Channel Flow Equations – development of the Department's open channel flow equation used on larger rivers.
- Development of Runoff Depth Map for Alberta – discusses the development of the Runoff Depth Map by the Department and its application to the design discharge.

The Department has developed tools that may be useful during bridge planning hydrotechnical design. These are available as described in Guide to Bridge Planning Tools. Tools of particular interest include:

- HIS – The Hydrotechnical Information System developed by the Department provides basic information about every bridge owned by the Department. Information may include year of construction, size, location, documented flood observations, hydrotechnical file histories and summaries, hydrotechnical inspections, and stream profiles (based on DEM data).
- Flow Profile – Performs 1D calculation of section averaged depths and velocities through a system of channel and structure elements. It is based on a combination of Gradually Varied Flow and Rapidly Varied Flow calculations. The software can be used to model multi-slope culverts and constricted bridge openings. This is the Department's preferred hydraulics modelling tool.

BPG 11
Stormwater Management at Rural Bridges

- Released July 2010
- Documents AT’s practice for stormwater management at rural stream crossings
- Aligns with AEnv “Stormwater Management Guidelines for the Province of Alberta

BPG 11

Stormwater Management at Rural Bridges

- Use of open channel ditches for the drainage system
- Provision of cross-drainage and ditch drainage outfalls at all natural watercourses
- Application of erosion and sedimentation control measures, where necessary (“Design Guidelines for Erosion and Sediment Control for Highways”, 2003).
- Bridge deck drainage utilizing deck drains and longitudinal grades to avoid lane encroachment during a design storm intensity (BPG 12)
- Use of natural outfalls with ditch drainage typically directed into low lying areas adjacent to the channel

BPG 12
Bridge Deck Drainage

- Released August 2010
- Practice for bridge deck drainage has been to use sufficient deck drains combined with optimized bridge geometry to avoid lane encroachment and local pooling
- Min. desirable longitudinal gradient for bridges of 1% (AT Bridge Structures Design Criteria, v. 6.1, Nov 2008)

BPG 12
Bridge Deck Drainage

- For safety reasons no lane encroachment is desirable
- If lane encroachment will occur, the scheme should be modified to eliminate the encroachment e.g. wider shoulder, larger drains, modified longitudinal grade
- If the lane encroachment cannot be eliminated a design exception may be considered with appropriate documentation and justification.

BPG 12
Bridge Deck Drainage

- Recent practice - use Rational Method for runoff flow rate estimation. Combine with Manning's equation for calculation of resulting flow depth adjacent to the barrier
- Many parameters used in these equations are based on recommendations in the "Hydraulic Engineering Circular 21 - Design of Bridge Deck Drainage" (FHWA, 1993).
- Values used in the Rational Method equation are:
  - runoff coefficient, C = 0.9,
  - rainfall intensity, i = 150 mm/hr, based on physical limits on driver visibility
- A roughness coefficient 'n' = 0.016 is used in the Manning equation.

BPG 13

Freeboard at Bridges

- Released August 2010
- Documents AT’s current freeboard practice for structures
- considers site specific factors where technically justified and documented

BPG 13
Freeboard at Bridges

- Is the minimum clearance between the bottom of the girders and the design highwater or ice elevation
- Allows the passage of drift, debris, and ice at highwater levels,
- Accommodates uncertainty in the design highwater elevation or the possibility of an event more extreme than the design event
- Not specifically applied at culverts due to the additional factors that apply in culvert sizing (Design Guidelines for Bridge Size Culverts, and Culvert Sizing Considerations)

BPG 13
Freeboard at Bridges

- Lower freeboard values can be considered if:
  - Lowering the gradeline by reducing the freeboard results in a significant cost reduction
  - There is a high degree of confidence in the design highwater level, and there is limited potential and/or history of drift or ice accumulation
- Thorough technical justification and documentation must be provided including consideration of costs, benefits, and risks. Department concurrence is required.
- Minimum freeboard of 0.3 m is required at the low end of all bridge structures over watercourses

BPG 14
Wildlife Passage at Stream Crossings

- Released August 2010
- Traditionally, stream crossings were not specially designed accommodate wildlife passage
- Recent increased attention to wildlife passage - EIAs and collision reduction program studies
- Costs and benefits associated with wildlife passage features should be documented for consideration

BPG 14
Wildlife Passage at Stream Crossings

- Factors that may affect the **potential benefit** to accommodating wildlife passage at a bridge site include:
  - Potential for animal collisions - function of the cross product of animals crossing the road and traffic along the road.
  - Valley characteristics - presence of steep, high banks either upstream or downstream. Will berms be effective?
  - Animal behavior - wildlife may prefer not to enter the valley. Fencing may be required adjacent to the roadway.
  - A separate crossing for wildlife may be preferable to incorporating measures into the bridge opening.

BPG 14

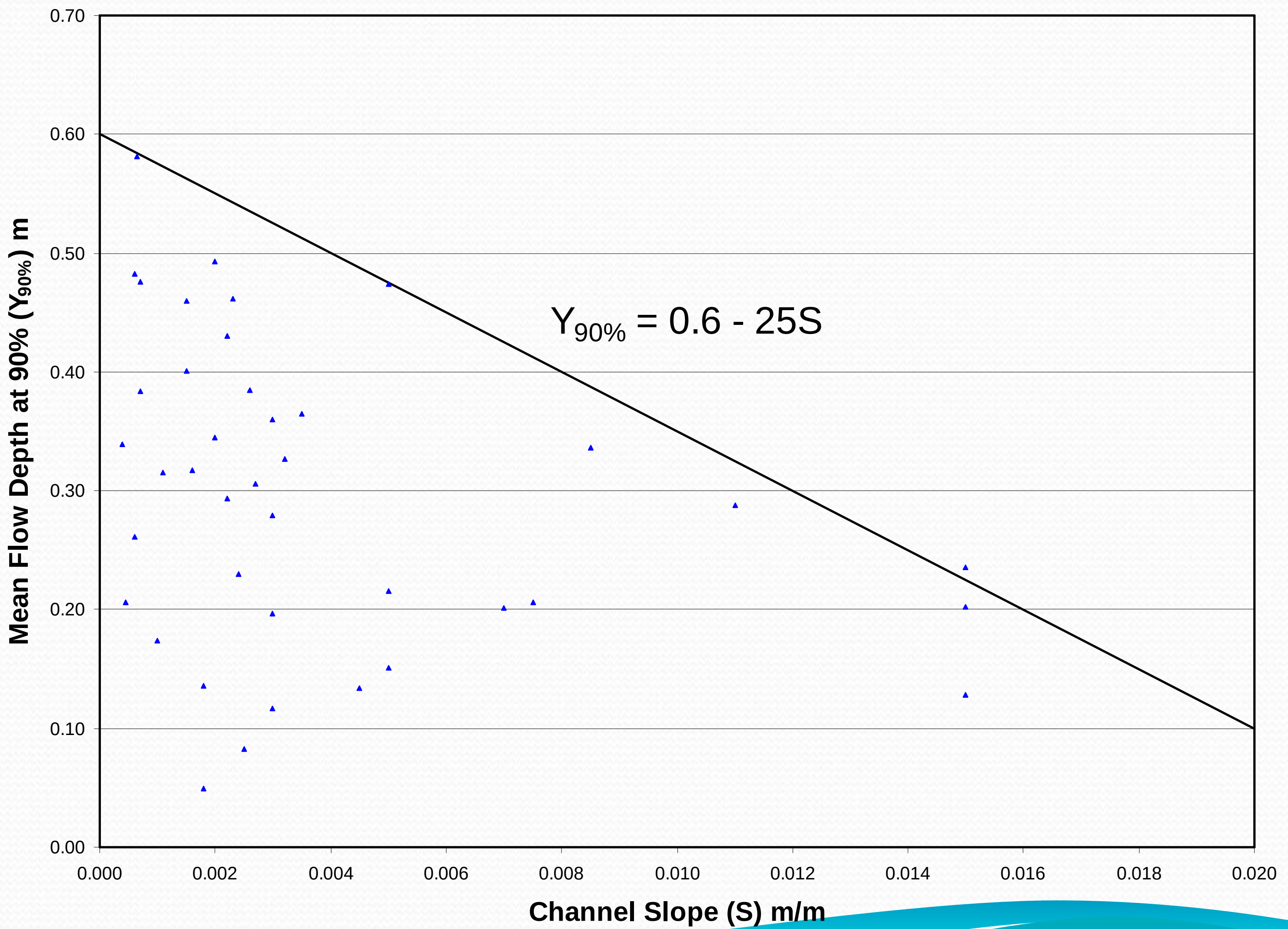
Wildlife Passage at Stream Crossings

- Factors that may affect the **potential costs** to accommodating wildlife passage at a bridge site include:
  - Width of the hydraulic opening may exceed the water width at low flow, e.g. mobile gravel bed streams
  - Berms for headslope stability or fill set-backs from top of bank may not need additional facilities for wildlife
  - Longer bridges required due to wildlife passage berms result in higher initial costs and maintenance requirements and reduced safety e.g. exposure to bridge rails and preferential icing
  - Vertical clearance for wildlife passage may result in raised gradelines may impact bridge cost and safety due to shorter sight distances

Fish Passage - Culverts

- Principles
  - Make culvert NOT a velocity barrier to fish
  - Pipe section averaged velocity <= typical channel velocity
- Design Flow Parameters
  - Evaluate at Q > normal, Q < flood
  - Calc Q in channel at $Y_{90\%}$
- Hydraulics
  - Burial results in increased A and decreased V
  - GVF in barrel (lose burial TW with length)

Fish Passage - Culverts



Fish Passage - Culverts

- Velocity Reduction Options - Effective
  - Increase Pipe Roughness – long, steep (normal flow)
  - Use Multiple Pipes – wide, shallow channels; blockage?
  - Use Wider Shape (Box, Ellipse) – cost (bridge?)
- Velocity Reduction Options – NOT Effective
  - Increase pipe diameter - mostly air space
  - Increase burial – ineffective >1 m, ponding, u/s barrier, excavation?

Fish Passage – Culverts

Steeper Pipes

- Increase Roughness
  - Effective – long, steep pipes (Burial TW lost, normal flow)
  - Install 0.2 m – 0.3 m thickness rock (e.g. class 1M, 1)
  - Install metal weirs at regular spacing to retain substrate
  - Substrate may also act as mitigation measure (DFO)

Fish Passage - Culverts

R	n - Class 1M (k ~ 0.7 m)	n - Class 1 (k ~ 1.2 m)
0.1	0.161	
0.2	0.079	0.141
0.3	0.064	0.095
0.4	0.057	0.079
0.5	0.053	0.071
0.6	0.050	0.065
0.7	0.048	0.062
0.8	0.047	0.059
0.9	0.046	0.057
1.0	0.045	0.055
1.1	0.044	0.054
1.2	0.044	0.053
1.3	0.043	0.052
1.4	0.043	0.051
1.5	0.042	0.050

- Estimate ‘n’
  - Based on roughness height of substrate ($k \sim 3.5D_{84}$)
  - Equate Manning and Chezy equations
  - Assume roughness applies to entire ‘P’ (low flow)
  - Sensitive to flow depth (R), iterative calculations

Fish Passage - Culverts

- Minimize the intrusion into the active flow area
- Culverts < 3 m diameter substrate holders should be 200 mm high for
- Culverts >= 3 m diameter use 300 mm high substrate holders
- Maximum spacing = substrate holder height divided by the slope of the culvert
- Consider installation on circumferential seams, with a minimum spacing of 7 m

Questions?