Fish Passage Toolbox:

Approaches to Solving Fish Passage Problems

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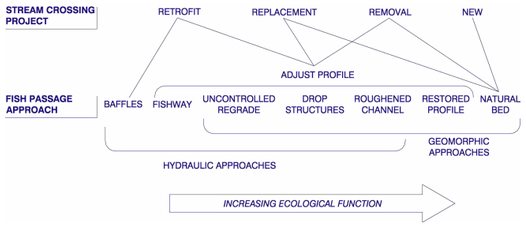


FISH PASSAGE APPROACHES

Geomorphic and **Hydraulic** approaches are the basic classifications of fish passage solutions used in California Department of Fish and Game's (CDFG) new Fish Passage Design & Implementation Manual (PART XII).

Solutions based on geomorphic principles mimic natural conditions and are flexible and resilient, while solutions based on hydraulic principles are more rigid and accommodating of site constraints. Each site is unique, and conditions will lead to individual solutions.

A **Hydraulic** solution is based on the premise that a structure with appropriate hydraulic conditions will allow target fish to swim through it.

A **Geomorphic** solution is based on the premise that a channel that simulates characteristics of the natural channel presents no more of a challenge to movement of organisms than the natural channel.

Many of the solutions combine both approaches.

References:

Love, M. and K. Bates. 2009. **Part XII: Fish Passage Design and Implementation.** California Salmonid Stream Habitat Restoration Manual. California Dept. of Fish and Game. 188 pp.

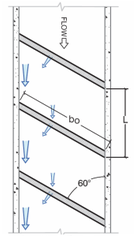
Bates, K. and M. Love. *In press*. **Design of Culvert Retrofits for Fish Passage.** USDA Forest Service, San Dimas Technology & Development Center.

HYDRAULIC APPROACHES

GEOMORPHIC APPROACHES

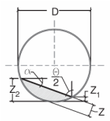
BAFFLES

Grub Creek Culvert Retrofit: Michael Love & Associates, Dragonfly Stream Enhancement



Angled Baffles (box culverts)

John Hatt Creek Slip-lined Culvert with Corner Baffles at High Passage Flow: CalTrans



Corner Baffles (circular & pipe-arch)

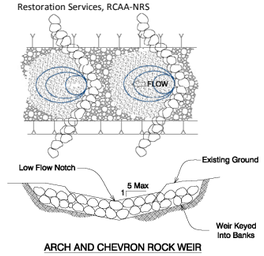
Baffles are a series of structures placed within a culvert to improve fish passage by increasing water depth at low flows and/or using roughness to decrease water velocity at high flows.

LIMITATIONS
- Designed for target fish species only, may exclude others
- Reduced culvert capacity
- Potential to catch debris

DESIGN CONSIDERATIONS
- Fish passage design flows
- Satisfy turbulence, depth, velocity & drop criteria
- Raises water level; may require downstream control structures
- Use baffle types that create a passage corridor along edge

DROP STRUCTURES

Chevron Rock Weirs Downstream of Morrison Gulch Culvert: Michael Love & Associates, Environmental Restoration Services, RCAA-NRS



ARCH AND CHEVRON ROCK WEIR

Drop Structures are constructed drops in the channel formed by individual weirs, sills, Newberry riffles, or chutes to steepen the channel profile above its natural slope. Each structure is independent from the next, with a distinct scour pool between structures.

Often constructed of rock, logs, concrete, or sheet pile.

LIMITATIONS AND CONSIDERATIONS
- Oversteepened profile typically limited to 3 to 5 percent
- More stable in entrenched channels with coarse bed material
- Drop height affects passage, scour depth, scour length, spacing & footing
- Crest shape affects bank scour, water depth, and structure stability
- Anticipate potential scour and vertical adjustment downstream of last structure

UNCONTROLLED REGRADE

Horse Creek Dam Removal: Stoecker Ecological, Los Padres NF, Michael Love & Associates

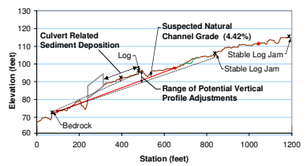
Headcutting Upstream of Culvert Replacement: Loss of alluvial channel bed, entrenchment of channel, and disconnected floodplain.

Uncontrolled Regrade allows a channel to self-adjust following removal of a knickpoint, constriction, or structure.

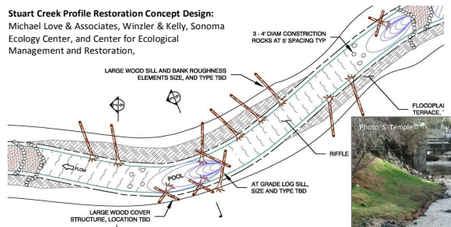
The "let it rip!" option.

LIMITATIONS AND CONSIDERATIONS
- Length of regrade predicted through geomorphic interpretation
- Volume, rate, and effects of sediment release should be assessed
- Potential for change in upstream channel stability, geomorphic type, and habitat

Predicted Extent of Headcutting from Project



RESTORED PROFILE



Stuart Creek Profile Restoration Concept Design: Michael Love & Associates, Winzler & Kelly, Sonoma Ecology Center, and Center for Ecological Management and Restoration,

San Pedro Creek Channel Restoration: Raised and stabilized an incised channel 12 ft, eliminating drop at culvert. Questa Engineering

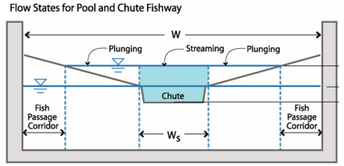
Profile Restoration of an incising channel to a natural, stable, and self sustaining condition can:
- Address fish passage
- Restore in-stream, riparian, and floodplain habitats
- Improve channel-floodplain interaction, reconnect side-channels
- Decrease sediment delivery by reversing bed & bank erosion

LIMITATIONS
- Largest & most expensive alternative
- Hydrologic & land-use changes within can prevent it from being self-sustaining or desirable
- Often requires cooperation and involvement of multiple landowners

FISHWAYS

Big Sulphur Creek Pool-and-Chute Fishway: Michael Love & Associates, Prunuske Chatham, Calpine Corp.

Flow States for Pool and Chute Fishway



Fishways are formal fish passage structures built steeper than more geomorphic types of structures, thus minimizing footprint with little risk of structural failure.
- Pool-and-weir fishway
- Pool-and-chute fishways
- Vertical slot fishways
- Denil/Alaska steeppass flumes

LIMITATIONS
- Designed for target fish species only, may exclude others
- Potential to catch debris

DESIGN CONSIDERATIONS
- Fish attraction: fishway flow, entrance location, hydraulics
- Passage flows & drop, depth, turbulence, velocity criteria
- Hydraulic transitions

GEOMORPHIC-BASED ROUGHNED CHANNELS

Grub Creek Plane-Bed Rock Ramp: Michael Love & Associates, Dragonfly Stream Enhancement

Gulch 7, Step-Pool Roughened Channel Culvert with Bed Retention Sills: Michael Love & Associates, Campbell Timber

Spanaway Creek Bypass Chutes-and-Pools Roughened Channel Around a Water Supply Dam: Kozmo Bates

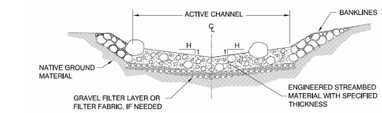
Woodacre Creek Roughened Channel Eliminates Culvert Outlet Drop: Marin County, Michael Love & Associates, Stetson Engineers

Little Browns Creek Roughened Channel: Trinity County, 5C Program, Michael Love & Associates

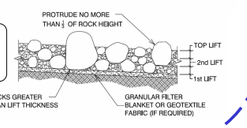
Geomorphic-Based Roughened Channels mimic the morphology of natural channels steeper than the adjacent channel. Used to control the channel profile while providing fish passage, they are stabilized with an immobile framework of large rock mixed with smaller material.

The bed structure creates hydraulic diversity suitable for passage of fish and other aquatic organisms. Channel types include:
- Plane-bed rock ramps
- Step-pools
- Chutes and pools
- Cascades

LIMITATIONS AND CONSIDERATIONS
- Roughened channel should not be steeper than the channel the fish naturally traverse.
- As the design slope and bed material diverges from the adjacent natural channel, the more risk and uncertainty involving channel stability and fish passage.
- Passage flows, turbulence, depth, velocity & drop criteria
- Special attention given to transitions



Engineered Streambed Material has two components: large rock forms a framework and smaller material fills the interstitial voids



NATURAL BED - STREAM SIMULATION

McGarvey Gulch Stream Simulation Squash-Pipe: Michael Love & Associates, Winzler & Kelly

Clarks Creek Bridge: Del Norte County, Winzler & Kelly, Michael Love & Associates

Woodacre Creek Stream Simulation Arch Culvert: Marin County, Michael Love & Associates, Stetson Engineers

Stream Simulation creates a channel that simulates characteristics of the natural channel that will present no more of a challenge to movement of organisms than the natural channel.

Bankfull channel dimensions, channel slope, bed material, and bedforms are simulated based on a nearby natural reference reach.

LIMITATIONS
- Generally limited to new or replacement stream crossings
- Large wood features and banks are simulated using rock
- Not well suited for incising or unstable channels

Poster/Illustrations: A. Llanos, M. Love, 2010