



SOLENO
MASTERING WATER SUSTAINABLY



KUSTOMFLO FISH BAFFLE DESIGN

Overview

Fish Baffles in HDPE pipes are a practical solution for supporting aquatic organisms' passage through culverts and other water crossings. By strategically placing baffles along the length of the pipe, water depth and flow velocity can be adjusted to align with swimming capabilities of target fish species. The baffles create resting zones and reduce turbulence, allowing fish to move upstream during routine and seasonal movements. KustomFlo pipes are lightweight, durable, and resistant to corrosion, making them well suited for integrating baffle systems.

Beyond ecological applications, baffles also provide hydraulic benefits. In many conveyance systems, they're used to dissipate energy, control flow velocity, and improve sediment distribution. In KustomFlo baffle systems, both the pipe and the baffles are fabricated from HDPE, creating a consistent material system. Material compatibility supports reliable attachment, consistent hydraulic behavior, and long-term performance.

Solen offers culvert solutions using structured HDPE pipes ranging from 24 to 136 inches in diameter, with baffle systems that can be custom designed to meet site-specific hydraulic and biological requirements. Since the baffles are manufactured of the same high-quality resin as KustomFlo pipes, baffles and reinforcements can be securely integrated across a range of sizes and configurations, making KustomFlo baffle integrated culverts ideal for both reline and direct burial applications.



Hydraulic Design of Culverts

The Federal Highway Administration identifies different strategies for designing structures that allow aquatic organisms to pass through roadway crossings. One strategy involves using very wide structures that span both the channel and floodplain, allowing aquatic organisms to move freely; however, these structures are typically more costly to install. Other designs reproduce or preserve natural stream characteristics, including slope, channel width, and bed materials, but often require a structure that matches the channel width to maintain stream behavior, which can also be costly. Another option focuses on controlling flow depth and velocity within the culvert by matching the stream's natural grade and substrate. This method typically results in smaller spanning structures with lower upfront costs, but with greater long-term maintenance needs, such as debris removal.

While effective in many contexts, these methods are not always feasible due to site constraints, existing infrastructure, or budget limitations. In such cases, fish baffles offer a practical solution within the hydraulic design approach, modifying flow patterns to reduce velocities, providing resting zones, and improving passage for target species.

Installation costs vary depending on the complexity of the chosen features. Compared to a culvert without baffles, baffle-integrated systems may require additional maintenance and inspection, with inspections typically once or twice per year, depending on site conditions. Culverts that drain a large watershed, and those with significant sediment loads and woody debris are generally recommended to be inspected after major storm events as well as at the conclusion of the rainy season.

It's important to note that this solution is not intended to support the passage of all fish species year-round. Instead, the fish baffles are designed to meet the needs of priority species during the most critical times of their life cycles.



Design Considerations

When designing fish baffles for KustomFlo pipes, the following factors should be considered:

- **Target fish species and swimming abilities**

Baffle design should reflect the swimming capabilities of the target species and other aquatic organisms that are expected to use the culvert during different seasonal migration periods. Factors such as swimming speed, burst speed, and endurance directly influence baffle height, spacing, and orientation. Properly sizing based on these biological constraints help ensure fish can move upstream effectively minimizing fatigue.

- **Hydraulic conditions: velocity, depth, and flow variability**

Baffles are intended to reduce water velocity and increase flow depth during lower flow conditions of a stream. The design must account for the range of anticipated seasonal flows, storm event frequency, and floods. As water flows past each baffle, velocity is reduced locally and redistributed across the cross section of the culvert, creating slower flow zones. Proper geometry and spacing ensure these zones overlap enough to provide a continuous pathway for fish.

- **Culvert slope and length**

Steeper slopes increase flow velocity and total elevation change, while longer culvert barrels increase the distance over which swimming effort must be sustained. As culvert length increases, fish are exposed to continuous flow for longer periods, and steeper slopes create more challenging hydraulic conditions which can lead to fatigue and an unsuccessful passage. Baffles help address these challenges by breaking the total elevation change into smaller increments and creating successive low-velocity zones that allow fish to rest and recover as they move upstream.

- **Structural attachment to HDPE pipe**

Pipe, baffles, and reinforcements are made from compatible materials, allowing them to work well together as a single, integrated system. This results in secure baffle connections that can handle hydraulic forces, debris impact, and long-term loading without weakening the pipe. The inherent strength and flexibility of KustomFlo pipes help ensure baffles remain firmly in place and perform as intended throughout the service life of the culvert.

- **Inspection schedule, maintenance access and debris management**

Baffles can increase the potential for sediment and debris accumulation. Designs should allow for reasonable access to inspect and clean culverts as needed, and baffle geometry should be selected to minimize debris buildup while still providing effective hydraulic control. Maintenance and inspection schedules should be established based on site-specific conditions.

Baffle Types

Common baffle types include:

- **Flat:** consist of simple plates installed at the pipe invert, typically extending partially across the culvert width. They provide a uniform hydraulic interruption without directing flow laterally.

- **Angled:** similar in form to a flat baffle but are installed at an incline relative to the pipe centerline and are typically arranged in an alternating left and right pattern along the culvert length.

- **Customized weir:** incorporates openings or shaped edges. The geometry may be configured to guide flow toward specific areas of the culvert or address unique passage or sediment considerations. The weirs can also contain low-flow orifices or notches to prevent ponding behind baffles.

The choice of baffle type will depend on the site-specific conditions and target species.



Regulatory Background

Fish passage at roadway crossings is governed by a combination of federal, state, and local regulatory requirements intended to protect aquatic species and maintain stream connectivity. At all levels, regulatory guidance seeks to ensure that culverts and similar structures minimize environmental impacts while continuing to meet transportation, hydraulic, safety, and budget requirements.

At a federal level, several agencies influence the planning and design of culverts and fish passages, each with a distinct regulatory role. For many states' Department of Transportation projects, the Federal Highway Administration (FHWA) plays a central role in establishing national design standards, hydraulic guidance, and aquatic organism passage expectations under the Federal-Aid Highway Program. The U.S. Environmental Protection Agency (EPA) oversees compliance with the Clean Water Act, focusing on protection of water quality, sediment transport, and aquatic habitat. The U.S. Fish and Wildlife Service provides technical oversight related to aquatic organisms' passage and protected species. Together these agencies, along with other federal entities, established the federal regulatory framework for designing baffle systems.

At a state level, agencies typically provide more site-specific criteria. In New York, for instance, fish passage at roadway crossings are primarily regulated by the New York State Department of Environmental Conservation (NYSDEC) under the Protection of Waters Program, with technical review conducted by the Division of Fish and Wildlife. NYSDEC guidance emphasizes stream continuity and ecological function by requiring sufficient water depth, acceptable velocities, turbulence control, and grading. The New York State Department of Transportation (NYSDOT) is responsible for implementing these requirements on transportation projects and coordinating with NYSDEC during project development. Soleno has experience supporting fish baffle installations on NYSDOT projects, applying applicable regulatory design requirements.

In the New England region, fish passage is also governed by a combination of agencies. Massachusetts regulates stream crossings through the Department of Environmental Protection (MassDEP), in coordination with the Division of Ecological Restoration (DER) and the Massachusetts Department of Transportation (MassDOT), with standards incorporated into state and federal permitting processes. New Hampshire is often referenced by New England states due to its established New Hampshire Stream Crossing Initiative (NHSCI.) The NHSCI is a multi-agency program created specifically to assess inventory, and prioritize stream crossings statewide for aquatic organism passage, geomorphic compatibility, and infrastructure conditions.

Installation, Inspection and Maintenance Guidelines

KustomFlo baffle systems should be installed following the recommendations provided in the KustomFlo Installation Guide, as well as any project-specific design documents. Baffles are fabricated and installed at the manufacturing facility, where the HDPE baffles are attached to the pipe wall.

Baffle spacing and dimensions are established by the project's engineering team and coordinated with the Soleno Sales Representative based on site-specific factors, including factors outlined in this guide, and other project considerations. The pipe must be installed in the order specified in the approved shop drawings to ensure baffle alignment and spacing.

Following installation, routine inspection and maintenance should be conducted to confirm that baffles are free of structural damage. Maintenance may include removal of accumulated debris or sediment, and repair or replacement of damaged baffles or welds. When properly installed, KustomFlo baffle systems provide a durable solution that supports aquatic organism passage while preserving culvert structural integrity.

Design Manuals & Engineering Guidance

- Federal Highway Administration (FHWA). Design for Fish Passage at Road Stream Crossings: Synthesis Report.
- Washington Department of Fish and Wildlife (WDFW). Design of Road Culverts for Fish Passage.
- New York State Department of Transportation (NYSDOT). Highway Design Manual, Chapter 8: Highway Drainage.
- Pennsylvania Fish and Boat Commission (PFBC). Culvert Designs for Fish Passage in Pennsylvania. Spotts, D.E., Division of Environmental Services

Regulatory & Programmatic Web Guidance

- New York State Department of Environmental Conservation (NYSDEC). Protection of Waters Program.
- New York State Department of Environmental Conservation (NYSDEC). Freshwater Fisheries Management and Research.
- New York State Department of Environmental Conservation (NYSDEC). Division of Fish and Wildlife Technical Guidance Memorandum GS 24 01.
- New Hampshire Stream Crossing Initiative. Overview.
- New York State Senate. Environmental Conservation Law – Fish Passage and Stream Protection Provisions. NYS Open Legislation.