



PDH-Pro.com

Introduction to Hydraulic Structures

Course Number: CE-02-712

PDH: 5

Approved for: AK, AL, AR, DE, FL, GA, IA, ID, IL, IN, KS, KY, LA, MD, ME, MI, MN, MO, MS, MT, NC, ND, NE, NH, NJ, NM, NV, NY, OH, OK, OR, PA, SC, SD, TN, TX, UT, VA, VT, WI, WV, and WY

State Board Approvals

Florida Provider # 0009553 License #868

Indiana Continuing Education Provider #CE21800088

Maryland Approved Provider of Continuing Professional Competency

New Jersey Professional Competency Approval #24GP00025600

North Carolina Approved Sponsor #S-0695

NYSED Sponsor #274

How Our Written Courses Work

This document is the course text. You may review this material at your leisure before or after you purchase the course.

After the course has been purchased, review the technical material and then complete the quiz at your convenience.

A Certificate of Completion is available once you pass the exam (70% or greater).

If a passing grade is not obtained, you may take the quiz as many times as necessary until a passing grade is obtained).

If you have any questions or technical difficulties, please call (508) 298-4787 or email us at admin@PDH Pro.com.





Module 1: Hydraulic Structures

Learning Objectives

By the end of this section, you will be able to:

- **Identify** the primary functions and types of hydraulic structures used in urban drainage and flood control.
- **Distinguish** between the operational roles of grade control structures, including drops and checks.
- **Evaluate** design considerations for public safety, maintenance, and environmental integration in hydraulic engineering.

Executive Summary: Hydraulic structures are essential engineered components used to manage water velocity, direction, and streambed stability. In urban drainage, their primary role is the controlled conversion and dissipation of energy to prevent erosion while balancing public safety, recreational use, and aesthetic integration.

Design Fundamentals

Hydraulic structures serve as the primary tools for guiding and controlling flow characteristics within a waterway. Proper application of these structures reduces long-term maintenance costs by aligning flow behavior with environmental and project constraints.

Key Functions of Hydraulic Structures

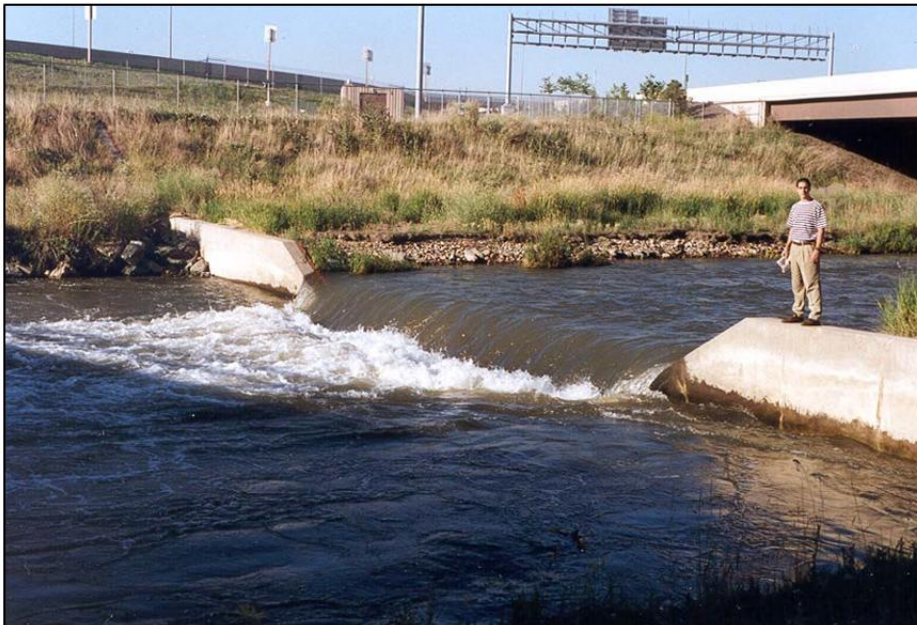
- **Flow Control:** Managing velocities, directions, and depths.
- **Bed Stability:** Controlling the elevation and slope of the streambed.
- **Configuration:** Maintaining the general geometry and stability of the waterway.



Photograph HS-1—Denver’s Harvard Gulch Flood Control Project introduced the baffle chute drop structure to urban flood control in 1966. Vegetation and time have made the structure part of the city’s urban poetry.

Scope and Methodology

This module focuses on structures for drainage and flood control channels rather than dam spillways. For larger or non-standard structures, **model testing** is recommended to verify performance.



Photograph HS-2—The Clear Creek I-25 vertical concrete drop structure was a “drowning machine” until it was retrofitted by CDOT with a 10:1 downstream face. (Photograph taken before retrofit.)

Channels Used for Boating

In waterways utilized for rafting, canoeing, or kayaking, designers must apply a standard of care consistent with public safety.

⚠ **Safety Constraint:** Designers **shall** avoid the creation of **reverse rollers** (submerged hydraulic jumps with upstream surface currents) which pose significant drowning risks.

💡 **Design Tip:** It is recommended to retain a **whitewater boating specialist** to assist in establishing design criteria for structures located on known boatable streams.

Channel Grade Control Structures

Grade control is achieved through two primary types of structures that dissipate energy to maintain mild upstream slopes.

- **Drop Structures:** These traverse the **entire waterway** and are designed to carry major flood events.
- **Check Structures:** These stabilize the **low-flow channel** only. During major floods, flow circumvents the check, but the structure prevents the low-flow channel from degrading and undermining the broader floodplain.

Wetland Channel Grade Control

Wetland environments require specialized stability measures to maintain ecological integrity.

- **Slope Limit:** Slopes should generally **not exceed 0.3%**.
- **Water Table Management:** If a trickle channel is utilized, it **should not lower** the wetland water table by more than **12 inches**.

Conduit Outlet Structures

These structures are specifically engineered to dissipate kinetic energy at the transition point where storm sewers or culverts discharge into open waterways. This prevents localized scour at the point of entry.

Bridges

While bridges allow waterways to remain largely undisturbed, piers and abutments often necessitate hydraulic evaluation.


⚠ **Safety Constraint:** Encroachments into the waterway **must** be evaluated for adverse hydraulic effects and **scour potential**.

Transitions and Constrictions

- **Transitions:** Used to change cross-sectional geometry, fit confined rights-of-way, or accelerate flow for high-velocity conveyance.
- **Constrictions:** May be used to purposely induce upstream spills into storage facilities, though they must be carefully designed to avoid unintended upstream flooding.

Bends and Confluences

Confluences present complex hydraulic conditions because flow rates from joining channels vary disproportionately over time.

 **Design Tip:** Specialized modeling is often required for confluences where **supercritical flow** or **hydraulic jumps** are anticipated.

Rundowns

Rundowns are hardened channels used to convey runoff from high bank elevations down to the channel invert or a detention facility.

- **Primary Purpose:** To prevent **erosion and head cutting** caused by concentrated side-slope runoff.

Energy Dissipation


Managing energy is the core of hydraulic design. It involves the manipulation of the **Total Energy Grade Line (EGL)**.

Energy Management Strategies

- **Dissipation:** Converting kinetic energy to heat/turbulence (e.g., via hydraulic jump).
- **Conservation:** Maintaining energy through transitions and bridges.
- **Conversion:** Shifting potential energy (elevation) to kinetic energy (velocity) under controlled conditions.

Maintenance

A structure is only as effective as its maintenance program.

 **Safety Constraint:** Suitable **maintenance access** must be provided for all drainage facilities. Designers must develop a plan that aligns with public works standards.

Structure Safety and Aesthetics

In urban environments, structures must balance technical performance with public interaction.

- **Hazard Avoidance:** Avoid "keepers" or reverse rollers.
- **Aesthetic Integration:** Use diverse materials, stepped configurations (like grouted sloping boulders), and landscaping/vegetation to enhance water quality and habitat.



Photograph HS-3—Stepped grouted sloping boulder drop structures such as in Denver’s Bible Park can be safe, aesthetic, and provide improved aquatic habitat besides performing their primary hydraulic function of energy dissipation.



Purchase this course to
see the remainder of
the technical materials.